NUEXCO

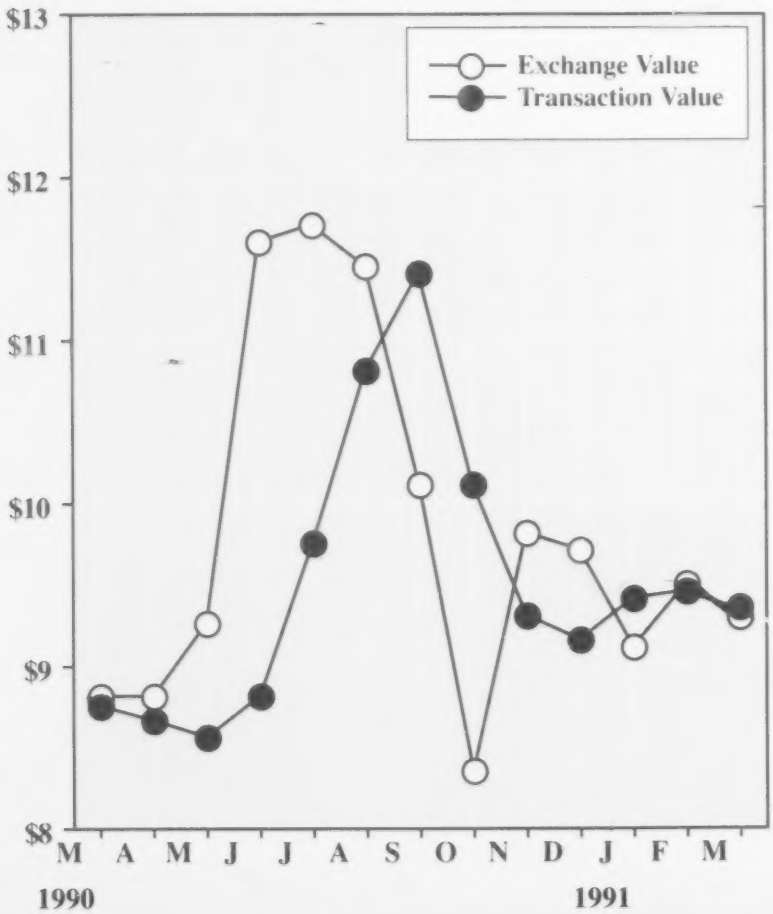
Monthly Report

April 1991 Number 272

USCEA Conference 15

Rössing Uranium Limited 22

Conversion and Enrichment in the Soviet Union 27



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Focus

- **Rössing Uranium Limited** 22

Rössing Uranium Limited is Namibia's largest employer, and the Rössing mine is the second largest uranium mine in the world. Yet Rössing is one of the lowest grade uranium deposits ever commercially exploited, with an average grade of only 0.035 w/o U_3O_8. To efficiently develop such a low-grade deposit, RUL uses extensive real-time cost analysis systems and has the highest rock production rate of any uranium mine in the world.

- **Conversion and Enrichment in the Soviet Union** 27

This article is based on information provided by Mr. Boris V. Nikipelov, First Deputy Minister of Atomic Energy and Industry, and his colleague, Mr. Anatoly A. Vlasov, during a recent visit to the Soviet Union by Contributing Editor R. Wesley Miller. Although some details remain classified, the article contains much previously unavailable information, such as a conversion process flow chart and photographs of a gas centrifuge enrichment facility.

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Market Values Summary

NUEXCO Market Values	This Report March 31, 1991	Last Report February 28, 1991	12 Months Ago March 31, 1990
EXCHANGE VALUE[1]	**$9.30**/lb equivalent U_3O_8	$9.50	$8.80
UF_6 VALUE[2]	**$27.50**/kg U as UF_6	$27.75	$24.40
LOAN RATE[3]	**3.5%**/annum	3.5%	3.5%
CONVERSION VALUE[4]	**$1.45**/lb U as UF_6	$1.45	$1.45
SWU VALUE[5] **(0.3% tails assay)**	**$52**/SWU	$50	$50
TRANSACTION VALUE[6]	**$9.35**/lb equivalent U_3O_8	$9.45	$8.75
Transactions	**10**	18	13
Months	**3**	3	3
Millions of Pounds	**3.0**	2.6	4.4

DEFINITIONS

1 The **Exchange Value** is NUEXCO's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.

2 The **UF_6 Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.

3 The **Loan Rate** is NUEXCO's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.

4 The **Conversion Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.

5 The **SWU Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of enrichment services could be concluded as of the date indicated.

6 The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:

a) Transactions closed within the previous three month period for which delivery is scheduled within one year of the transaction date;

b) At least ten transactions;

c) Transactions involving a sum total of at least 2 million pounds equivalent U_3O_8.

DERIVATIONS AND COMMENTS

- All **Market Values** are expressed in terms of US$.
- All **Market Values** are based on:
  - Data from recently completed transactions.
  - Data from pending transactions.
  - Firm bids to buy or borrow, and firm offers to sell or lend.
  - Prices purchasers or rates borrowers have expressed a willingness to pay, but for which NUEXCO is not aware of firm bids to buy or borrow and prices sellers or rates lenders have expressed a willingness to accept, but for which NUEXCO is not aware of firm offers to sell or lend.
- Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these **Market Values**.
- In the determination of prices, NUEXCO does not consider charges for transportation other than that customarily provided by suppliers.
- The prices of services or materials delivered under long-term contracts with primary suppliers are not considered in the determination of the listed values.
- For the **SWU Value**, NUEXCO converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U^{235} and a product assay of 3.0 weight-percent U^{235}, assuming feed costs corresponding to the NUEXCO **Exchange Value** and **Conversion Value** determined as of the same date.
- In calculating the **Transaction Value**, NUEXCO does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future **Exchange Values** or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it can not currently be determined.
- The sample time for the **Transaction Value** is extended as necessary to satisfy the minima for the number of transactions and quantity of material. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

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MARKET REVIEW

MARCH MARKET REVIEW

(as of March 31, 1991)

OVERVIEW

The uranium market softened somewhat during March; both the Exchange Value and UF_6 Value declined slightly. The Exchange Value fell to $9.30 per pound U_3O_8 and the UF_6 Value declined to $27.50 per kgU as UF_6. Seven near-term natural uranium sales are reported, totalling nearly one million pounds equivalent U_3O_8. In addition, over 1.2 million pounds equivalent U_3O_8 changed hands in four enriched uranium product (EUP) sales.

Total year-to-date market volume (**Table 1**) equals only 5.0 million pounds equivalent U_3O_8; this is over six million pounds less than 1990's record first quarter volume. More cautious buyers and sellers, higher prices, and more discretionary demand thus far this year account for the difference. Moreover, market volume has traditionally been greatest during the second quarter, exceeding 21 million pounds last year. In comparison, total volume for the entire year of 1988 failed to reach 15 million pounds.

The Loan Rate and Conversion Value remained unchanged at 3.5 percent per annum, and $1.45 per pound U as UF_6, respectively. No conversion sales are reported, but two natural uranium loans were initiated totalling over 1.1 million pounds equivalent U_3O_8.

The SWU Value climbed two dollars, to $52 per SWU. Six enrichment sales, including the four EUP transactions mentioned above, are reported for the month, totalling almost 400 thousand SWU.

Table 1
NEAR-TERM URANIUM SALES SUMMARY

	March 1991		Year-to-Date	
	No. of Sales	Volume[1]	No. of Sales	Volume[1]
Concentrates	3	0.5	14	2.2
Natural UF_6	4	0.4	6	0.9
EUP	4	1.2	7	1.9
Total[2]	**11**	**2.2**	**27**	**5.0**

[1] million pounds equivalent U_3O_8
[2] columns may not total due to independent rounding

NATURAL URANIUM AND CONVERSION

The **Exchange Value** declined to **$9.30** per pound U_3O_8 on March 31, a two-percent drop. A lack of firm demand, coupled with the presence of motivated sellers, characterized the market at month end. Demand was largely discretionary; buyers have been reluctant to commit to new near-term purchases anticipating a weaker spot market later in the year. Only three near-term concentrates sales are reported for a total exceeding 500 thousand pounds equivalent U_3O_8. A utility, an intermediary, and a producer made up the three buyers. The sales were all concluded at prices near the March 31 Exchange Value.

* * *

The softening in the uranium market was also reflected by the decline in the **UF_6 Value**, which fell $0.25, to **$27.50** per kgU as UF_6. Four natural UF_6 sales, totalling nearly 450 thousand pounds equivalent U_3O_8, are reported. All occurred at prices near the March 31 UF_6 Value and call for delivery during second quarter 1991. Two utilities and two European intermediaries purchased the UF_6 from US intermediaries.

For only the second time in the history of the UF_6 Value, UF_6 is selling at a level exactly equal to the sum of the values of its components (**Figure 1**), indicating that buyers are apparently indifferent to the form of uranium purchased. The only other time this occurred was in May 1985, the second month the UF_6 Value was ever published.

* * *

In the long-term uranium market, four transactions are reported. Three intermediaries and one producer sold six million pounds equivalent U_3O_8 for delivery during the period 1991-1998. Six other utilities continued to evaluate long-term offers at month end.

* * *

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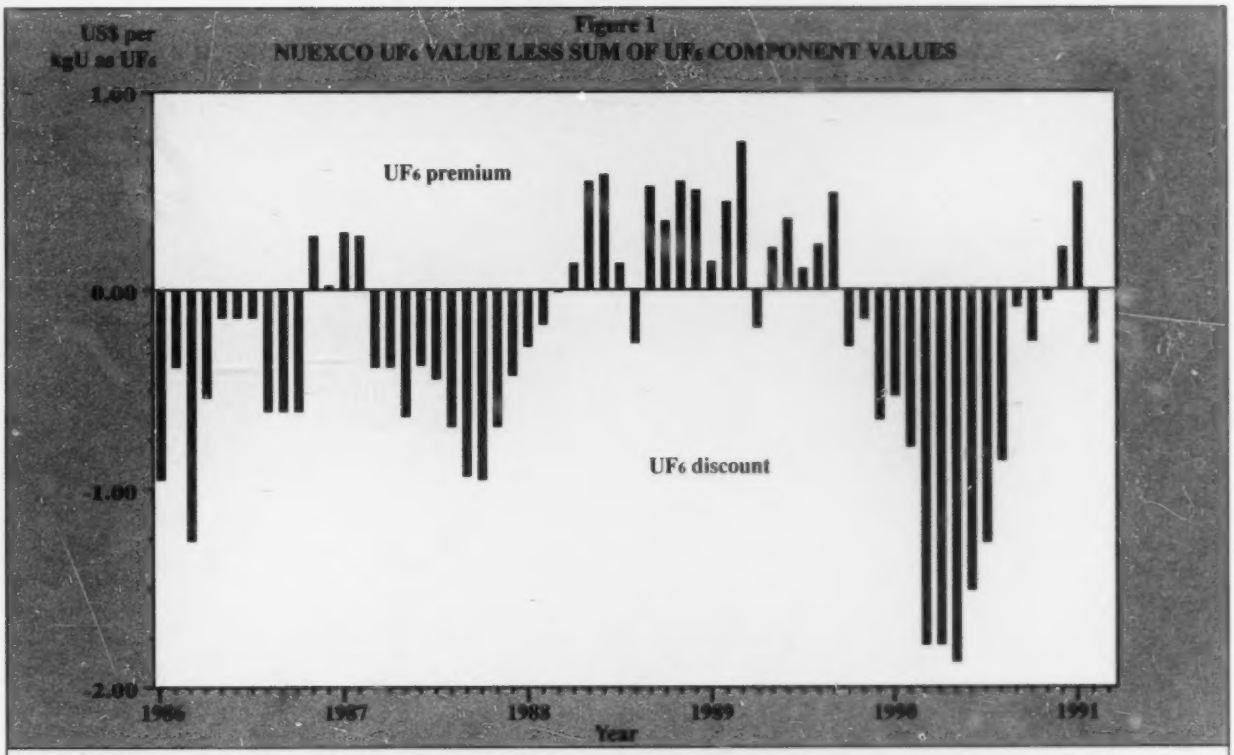

Figure 1
NUEXCO UF_6 VALUE LESS SUM OF UF_6 COMPONENT VALUES

[1] UF_6 Value – [(EV x 2.61285) + (CV x 2.20462)]. If this expression exceeds zero, that represents a UF_6 premium relative to the sum of its components. If the expression is less than zero, it represents a discount.

The **Transaction Value** dropped $0.10, to **$9.35** per pound U_3O_8 based on 19 transactions over 3 months involving 3.0 million pounds equivalent U_3O_8. The difference between the Transaction Value and the Exchange Value remained at $0.05 for a second month, as the Exchange Value has been relatively stable for the past five months (within a $0.70 range). Consequently, the Transaction Value has settled near the same level.

* * *

Active uranium supply decreased slightly in March, slipping from 5.4 million pounds, to **5.3** million pounds equivalent U_3O_8. Conversely, **active uranium demand** increased, jumping from 2.5 million pounds, to **3.9** million pounds equivalent U_3O_8. As a result, the **supply-demand ratio** fell to **1.4**.

Table 2
NEAR-TERM SUPPLY/DEMAND SUMMARY

	Active Supply [1]	Active Demand [1]
• Uranium (thousand lbs equivalent U_3O_8)	5,300	3,875
• Supply/Demand Ratio:	1.4	
• Loan (thousand lbs equivalent U_3O_8)	8,500	0
• Conversion (thousand lbs U as UF_6)	755	350
• SWU (thousand SWUs)	575	280

[1] Supply and Demand tables in the Market Review section of this Report provide details for each category.

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MARKET REVIEW

The **Loan Rate** remained unchanged at **3.5** percent per annum. Two loans are reported totalling over 1.1 million pounds equivalent U_3O_8. Intermediaries borrowed from utilities in both transactions. Loan supply declined by over 800 thousand pounds, but still exceeds 8.5 million pounds equivalent U_3O_8 (**Table 2**).

* * *

The **Conversion Value** also is unchanged, remaining at **$1.45** per pound U as UF_6 for the 13th consecutive month. No conversion transactions are reported from March.

* * *

ENRICHMENT SERVICES AND ENRICHED URANIUM PRODUCT

The **SWU Value** increased two dollars, to **$52** per SWU. SWU sales late in the month occurred near or slightly above the March 31, 1991 SWU Value. In EUP sales earlier in the month, the SWU component could be evaluated at levels nearer the February 28 SWU Value. The market's current tendency to sell EUP at a discount to the sum of the values of the contained SWU and feed components makes price evaluation of the individual components subject to wide interpretation.

Six SWU sales are reported from March totalling almost 400 thousand SWU. Of these sales, four involved SWU contained in EUP for a total of almost 300 thousand SWU and 1.2 million pounds equivalent U_3O_8.

Table 3
ENRICHMENT PRICES
(March 31, 1991)

Prices	This Month Report 272	Last Month Report 271	12 Months Ago Report 260
NUEXCO SWU Value ($US per SWU)	52	50	50
US DOE SWU prices: ($US per SWU)			
USEC	117.85[1]	117.85[1]	117.85[1]
AFC	153.00[3]	153.00[3]	153.00[3]
Requirements	157.00[3]	157.00[3]	157.00[3]
Incentive Price (IP2)[4]	100.60[4]	100.60[4]	90.00[5]
Calculated worth of enriched UF_6[6]: ($US per KgU as UF_6)			
2.0 w/o U_{235}	202	201	193
2.5 w/o U_{235}	279	277	267
3.0 w/o U_{235}	359	355	343
3.5 w/o U_{235}	440	435	421
4.0 w/o U_{235}	522	516	500
4.5 w/o U_{235}	605	598	579

[1] Effective 10/1/89 to 9/30/91.
[2] Effective 10/1/87 to 9/30/89.
[3] Effective since 10/1/84.
[4] IP2: Effective 10/1/90 to 9/30/91, for up to 30% of annual requirements.
[5] Used Incentive Price IP1 – effective 10/1/86 to 9/30/90, for up to 30% of annual requirements.
[6] Calculated using the NUEXCO Exchange Value, Conversion Value, SWU Value and 0.30 w/o tails assay.

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RECENT TRANSACTIONS

Uranium Sales[1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity (thousand pounds equivalent U_3O_8)	Price Within Percentage Range[2] of Current Exchange or UF_6 Value	Buyer	Seller	Remarks
5058	1991	Less Than 50	98-102	Utility	Intermediary	UF_6
5059	1991	50-100	90-97	Utility	Intermediary	
5060	1991	Less Than 50	98-102	Intermediary	Intermediary	UF_6
5062	1991	101-300	98-102	Utility	Intermediary	UF_6
5065	1994-1998	301-600	See Remarks	Utility	Intermediary	UF_6, Base Price Escalated
5067	1991	301-600	98-102	Producer	Intermediary	
5068	1991-1995	1,000-3,000	See Remarks	Producer	Producer	Base Price Escalated
5071	1991	101-300	98-102	Intermediary	Intermediary	UF_6
5072A	1991	Less Than 50	See Remarks	Fabricator	Intermediary	Contained In EUP
5073A	1991	50-100	See Remarks	Utility	R	Contained In EUP
5074A	1991	301-600	See Remarks	Intermediary	Fabricator	Contained In EUP
5076	1992-1996	1,000-3,000	See Remarks	Utility	Intermediary	Base Price Escalated
5077A	1991	601-1,000	See Remarks	Utility	Intermediary	Contained In EUP
5078	1991	50-100	98-102	Intermediary	Utility	
5079	1992-1996	1,000-3,000	See Remarks	Utility	Intermediary	Base Price Escalated

R means that NUEXCO either does not know, or that NUEXCO has restricted that information to protect client or source confidentiality.

[1] Transactions listed are not limited to those in which NUEXCO was involved, but also include others of which NUEXCO is aware. NUEXCO may delay reporting some transactions in order to protect proprietary information.

[2] The ranges *Below 90, 90-97, 98-102, 103-110, Above 110*, represent percentages (rounded to whole numbers) of the appropriate current Exchange Value or UF_6 Value. The endpoints of each range are included within that range.

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MARKET REVIEW

RECENT TRANSACTIONS

Natural Uranium Loans [1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity (thousand pounds equivalent U_3O_8)	Price Within Percentage Range [2] of Current Loan Rate	Borrower	Lender	Remarks
5069	1991	601-1,000	Above 110	Intermediary	Utility	
5070	1991	301-600	98-102	Intermediary	Utility	

Conversion Sales [1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity (thousand pounds of U equivalent)	Price Within Percentage Range [2] of Current Conversion Value	Buyer	Seller	Remarks
No Conversion Sales are reported						

Enrichment Sales [1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity [3] (thousand SWU)	Price Within Percentage Range [2] of Current SWU Value [4]	Buyer	Seller	Remarks
5072B	1991	Less Than 50	See Remarks	Fabricator	Intermediary	Contained in EUP
5073B	1991	Less Than 50	See Remarks	Utility	R	Contained in EUP
5074B	1991	50-100	See Remarks	Intermediary	Fabricator	Contained in EUP
5075	1991	50-100	98-102	Utility	Producer	
5077B	1991	101-300	See Remarks	Utility	Intermediary	Contained in EUP
5081	1991	Less Than 50	98-102	Utility	Intermediary	

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[2] The ranges *Below 90, 90-97, 98-102, 103-110, Above 110*, represent percentages (rounded to whole numbers) of the appropriate current Market Value. The endpoints of each range are included within that range.

[3] If tails assay is unknown or unspecified, NUEXCO's calculation of SWU quantity assumes 0.30 w/o tails assay.

[4] Prices are usually normalized to 0.30 w/o tails assay. When prices and SWU values are expressed as discounts from a reference price (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage price range is based on the discounted prices, not on the reference price.

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SUPPLY AND DEMAND

Uranium Supply

NUEXCO Project Number	Quantity (Thousand Pounds equivalent U_3O_8) Spot or Near-term[1]	Intermediate or Long-term[2]	Delivery Period	Remarks
AVAILABLE FOR SALE:				
ACTIVE				
90-1078A	700	1,045 per year	1991-1993	UF_6e
90-1227	500	—	1991	
90-1231	500	500 per year	1991-1995	
90-1501	3,000	1,000 per year	1991-1995	U_3O_8/UF_6
91-1060	100	—	1991	
91-1502*	500	—	1991	
Total	**5,300**			
INACTIVE	**4,100**			
AVAILABLE FOR LOAN:				
ACTIVE				
90-1016	1,000	—	—	U_3O_8
90-1230	1,000	—	—	U_3O_8
90-1260	1,000	—	—	UF_6
90-1275	100	—	—	U_3O_8
91-1018	500	—	—	U_3O_8
91-1034	1,000	—	—	U_3O_8
91-1084*	3,900	—	—	U_3O_8
Total	**8,500**			
INACTIVE	**1,000**			

*New or revised since last month.

[1] For delivery within one year, measured from the date of this Report. This category excludes material deliverable within one year under other than spot or near-term contracts.

[2] For delivery beyond one year, measured from the date of this Report.

Active Projects reclassified as Inactive since last month: *none*
Active Projects removed since last month: 88-1182, 90-1056, 91-1009, 91-1249

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SUPPLY AND DEMAND

Uranium Demand

NUEXCO Project Number	Quantity (Thousand Pounds equivalent U_3O_8) Spot or Near-term [1]	Intermediate or Long-term [2]	Delivery Period	Remarks
INQUIRIES TO PURCHASE:				
ACTIVE				
90-1100A	45	—	1991	UF_6e
90-1289	210	—	1991	
91-1010A*	85	—	1991	UF_6e
91-1040*	1,960	—	1991-1992	UF_6
91-1045	120	—	1991	
91-1067*	350	—	1991	
91-1071A*	325	—	1991	UF_6e
91-1073*	100	—	1991	U_3O_8/UF_6
91-1075*	600	—	1991	
91-1080A*	80	—	1991	UF_6e
90-1291	—	100 per year	1991-1995	
91-1014A	—	6,800	1992-2001	UF_6e
91-1017	—	300 per year	1995-2000	
91-1038	—	130 per year	1992-1996	
91-1054	—	1,200	1992-1997	
91-1064*	—	165 per year	1993-1997	U_3O_8/UF_6
91-1074*	—	200 per year	1993-1998	U_3O_8/UF_6
Total	**3,875**			
INACTIVE	**2,590**			

INQUIRIES TO BORROW: *No inquiries to borrow are reported*

* New or revised since last month.

[1] For delivery within one year, measured from the date of this Report. This category excludes material deliverable within one year under other than spot or near-term contracts.

[2] For delivery beyond one year, measured from the date of this Report.

Active Projects reclassified as Inactive since last month: *none*
Active Projects removed since last month: 91-1003A, 91-1029A, 91-1037, 91-1048, 91-1061

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SUPPLY AND DEMAND

Conversion Supply And Demand

NUEXCO Project Number	Quantity (Thousand Pounds U as UF_6) Within 3 Years [1]	Beyond 3 Years [1]	Delivery Period	Remarks
AVAILABLE FOR SALE:				
ACTIVE				
91-1077*	55	—	1991	
91-1500	300	—	1991	
91-1501	400	—	1991	
Total	**755**			
INACTIVE	*None reported*			
INQUIRIES TO PURCHASE:				
ACTIVE				
91-1085*	350	2,950	1993-1998	
Total	**350**			
INACTIVE	*None reported*			

* New or revised since last month.

[1] Measured from the date of this Report.

Active Projects reclassified as Inactive since last month: *none*
Active Projects removed since last month: 91-1003C, 91-1033

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MARKET REVIEW

SUPPLY AND DEMAND

SWU Supply And Demand

NUEXCO Project Number	Quantity (Thousand SWUs) Spot or Near-term [1]	Intermediate or Long-term [2]	Delivery Period	Remarks
AVAILABLE FOR SALE:				
ACTIVE				
88-1006	150	—	1991	
90-1078B	200	435 per year	1991-1993	UF6e
91-1008	75	—	1991	
91-1032	150	—	1991	
90-1500	—	1,000	1991 on	
Total	**575**			
INACTIVE	**500**			
INQUIRIES TO PURCHASE:				
ACTIVE				
90-1100B	15	—	1991	UF6e
90-1224*	40	1,920	1991-2001	
91-1010B*	20	—	1991	UF6e
91-1023	60	120	1991-1995	
91-1069*	30	—	1991	
91-1071B*	95	—	1991	UF6e
91-1080B*	20	—	1991	UF6e
90-1094	—	500	1992-2000	
90-1181	—	1,500	1996-2001	
90-1196	—	60 per year	1995 on	
90-1301	—	1,000 per year	1995-2000	UF6e
91-1014B	—	1,770	1992-2001	UF6e
91-1027	—	55 per year	1996-2000	
91-1028	—	125	1995-1996	
91-1055*	—	180	1992	UF6e
91-1063*	—	15 per year	1995-1998	
91-1066*	—	320	1995-2000	
91-1083*	—	150 per year	1996-1998	
Total	**280**			
INACTIVE	**150**			

*New or revised since last month.

[1] For delivery within one year, measured from the date of this Report. This category excludes SWU deliverable within one year under other than spot or near-term contracts.

[2] For delivery beyond one year, measured from the date of this Report.

Active Projects reclassified as Inactive since last month: *none*
Active Projects removed since last month: 91-1003B, 91-1029B, 91-1057

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MARKET VALUES EXPRESSED IN SELECTED CURRENCIES

Exchange Value[1]

Country (currency)	per lb equivalent U_3O_8 as Concentrates			per kg U as Concentrates		
	This Month (Mar. 31, 1991)	Last Month (Feb. 28, 1991)	12 Months Ago (Mar. 31, 1990)	This Month (Mar. 31, 1991)	Last Month (Feb. 28, 1991)	12 Months Ago (Mar. 31, 1990)
Australia (dollar)	12.00	12.10	11.70	31.20	31.46	30.41
Belgium (franc)	326.43	297.62	309.10	848.65	773.74	803.58
Canada (dollar)	10.77	10.94	10.31	28.01	28.44	26.81
EC (ecu)	7.75	7.06	7.32	20.15	18.36	19.04
Finland (markka)	37.48	34.84	35.29	97.45	90.58	91.74
France (franc)	53.68	49.18	50.25	139.56	127.86	130.63
Germany (mark)	15.86	14.46	14.93	41.24	37.60	38.82
Italy (lira)	11,805	10,802	11,011	30,690	28,082	28,626
Japan (yen)	1,314	1,254	1,377	3,415	3,261	3,579
Netherlands (guilder)	17.88	16.30	16.82	46.48	42.37	43.72
So. Africa (comm. rand)	25.40	24.39	23.33	66.04	63.41	60.65
So. Korea (won)	6,749	6,812	6,086	17,547	17,708	15,822
Spain (peseta)	983.09	900.13	956.11	2,556	2,340	2,486
Sweden (krona)	57.27	53.64	53.95	148.88	139.46	140.27
Switzerland (franc)	13.52	12.50	13.17	35.15	32.50	34.23
Taiwan (dollar)	250.36	253.65	232.32	650.87	659.44	603.99
UK (pound)	5.34	4.95	5.38	13.89	12.88	13.99
US (dollar)	9.30	9.50	8.80	24.18	24.70	22.88

Transaction Value[1]

Country (currency)	per lb equivalent U_3O_8 as Concentrates			per kg U as Concentrates		
	This Month (Mar. 31, 1991)	Last Month (Feb. 28, 1991)	12 Months Ago (Mar. 31, 1990)	This Month (Mar. 31, 1991)	Last Month (Feb. 28, 1991)	12 Months Ago (Mar. 31, 1990)
Australia (dollar)	12.06	12.04	11.63	31.37	31.30	30.24
Belgium (franc)	328.19	296.05	307.34	853.21	769.67	799.02
Canada (dollar)	10.83	10.88	10.26	28.16	28.29	26.66
EC (ecu)	7.79	7.02	7.28	20.25	18.26	18.93
Finland (markka)	37.68	34.66	35.09	97.97	90.10	91.22
France (franc)	53.97	48.92	49.96	140.31	127.19	129.89
Germany (mark)	15.95	14.39	14.85	41.46	37.40	38.60
Italy (lira)	11,868	10,745	10,948	30,855	27,934	28,464
Japan (yen)	1,321	1,248	1,369	3,433	3,244	3,559
Netherlands (guilder)	17.97	16.21	16.72	46.73	42.15	43.47
So. Africa (comm. rand)	25.54	24.26	23.20	66.40	63.08	60.31
So. Korea (won)	6,786	6,776	6,051	17,641	17,615	15,732
Spain (peseta)	988.37	895.40	950.67	2,570	2,328	2,472
Sweden (krona)	57.57	53.36	53.65	149.68	138.72	139.47
Switzerland (franc)	13.59	12.44	13.09	35.34	32.33	34.03
Taiwan (dollar)	251.70	252.32	231.00	654.37	655.97	600.56
UK (pound)	5.37	4.93	5.35	13.97	12.81	13.91
US (dollar)	9.35	9.45	8.75	24.31	24.57	22.75

[1] Calculated using currency exchange rates published in *The Wall Street Journal* on the last working day of the month.

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MARKET REVIEW

Market Values Expressed In Selected Currencies

Conversion Value[1]

Country (currency)	per lb U as UF_6			per kg U as UF_6		
	This Month (Mar. 31, 1991)	Last Month (Feb. 28, 1991)	12 Months Ago (Mar. 31, 1990)	This Month (Mar. 31, 1991)	Last Month (Feb. 28, 1991)	12 Months Ago (Mar. 31, 1990)
Australia (dollar)	1.87	1.85	1.93	4.12	4.07	4.25
Belgium (franc)	50.90	45.43	50.93	112.20	100.15	112.28
Canada (dollar)	1.68	1.67	1.70	3.70	3.68	3.75
EC (ecu)	1.21	1.08	1.21	2.66	2.38	2.66
Finland (markka)	5.84	5.32	5.81	12.88	11.72	12.82
France (franc)	8.37	7.51	8.28	18.45	16.55	18.25
Germany (mark)	2.47	2.21	2.46	5.45	4.87	5.42
Italy (lira)	1,841	1,649	1,814	4,058	3,635	4,000
Japan (yen)	204.80	191.47	226.85	451.51	422.12	500.11
Netherlands (guilder)	2.79	2.49	2.77	6.15	5.48	6.11
So. Africa (comm. rand)	3.96	3.72	3.84	8.73	8.21	8.47
So. Korea (won)	1,052	1,040	1,003	2,320	2,292	2,211
Spain (peseta)	153.28	137.39	157.54	337.92	302.89	347.32
Sweden (krona)	8.93	8.19	8.89	19.68	18.05	19.60
Switzerland (franc)	2.11	1.91	2.17	4.65	4.21	4.78
Taiwan (dollar)	39.03	38.72	38.28	86.06	85.35	84.39
UK (pound)	0.83	0.76	0.89	1.84	1.67	1.95
US (dollar)	1.45	1.45	1.45	3.20	3.20	3.20

SWU Value And UF_6 Value[1]

Country (currency)	SWU Value at 0.30 w/o Tails Assay			UF_6 Value per kg U as UF_6		
	This Month (Mar. 31, 1991)	Last Month (Feb. 28, 1991)	12 Months Ago (Mar. 31, 1990)	This Month (Mar. 31, 1991)	Last Month (Feb. 28, 1991)	12 Months Ago (Mar. 31, 1990)
Australia (dollar)	67.10	63.69	66.47	35.48	35.35	32.44
Belgium (franc)	1,825	1,566	1,756	965.25	869.36	857.04
Canada (dollar)	60.24	57.58	58.60	31.86	31.96	28.60
EC (ecu)	43.33	37.16	41.61	22.91	20.62	20.31
Finland (markka)	209.58	183.37	200.50	110.84	101.77	97.84
France (franc)	300.16	258.85	285.50	158.74	143.66	139.33
Germany (mark)	88.69	76.12	84.83	46.90	42.24	41.40
Italy (lira)	66,007	56,850	62,563	34,907	31,552	30,531
Japan (yen)	7,345	6,602	7,822	3,884	3,664	3,817
Netherlands (guilder)	99.96	85.78	95.55	52.86	47.61	46.63
So. Africa (comm. rand)	142.04	128.37	132.56	75.12	71.25	64.69
So. Korea (won)	37,739	35,850	34,578	19,958	19,897	16,874
Spain (peseta)	5,497	4,738	5,432	2,907	2,629	2,651
Sweden (krona)	320.20	282.33	306.56	169.33	156.69	149.60
Switzerland (franc)	75.60	65.80	74.81	39.98	36.52	36.51
Taiwan (dollar)	1,400	1,335	1,320	740.30	740.93	644.17
UK (pound)	29.88	26.07	30.57	15.80	14.47	14.92
US (dollar)	52.00	50.00	50.00	27.50	27.75	24.40

[1] Calculated using currency exchange rates published in *The Wall Street Journal* on the last working day of the month.

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RECENT DEVELOPMENTS

Australia

In an unexpected move, Mr. John Kerin, Australia's Federal Minister for Primary Industries and Energy, came out strongly for the abolition of the country's three-mine policy. Mr. Kerin's new position was outlined in a submittal to the Australian Labor Party's (ALP) Uranium Review Committee, which is charged with making policy recommendations at the ALP's June 1991 national conference. Uranium mining has been a singularly divisive issue within the ALP for more than 15 years, and Mr. Kerin, together with Prime Minister Bob Hawke and a number of their predecessors, have historically gone to some lengths to avoid confrontation with the environmental lobby and the ALP's left wing.

Mr. Kerin's letter describes the three-mine policy as illogical, hampering development, and doing nothing to meet public concerns about the environment, health and safety, nonproliferation, and Aboriginal welfare. The government is pushing for the adoption of what can be described as a pragmatic market view. By taking this position, the government is indicating that, while recognizing current market difficulties, it wants to avoid freezing Australia out of the market opportunities that it anticipates will develop in the mid to late 1990s.

It was also reported in March that Cogema was close to concluding a deal in which it would acquire a substantial share of Queensland Mines Limited's (QML) remaining uranium assets. In 1990, Nukem acquired QML's three long-term contracts and its uranium stockpile of over 6.5 million pounds U_3O_8. The assets in which Cogema would acquire an interest include: the Nabarlek 2 deposit; the Nabarlek mill; and QML's highly-prospective Arnhemland exploration leases. QML is expected to retain an interest in these assets, contrary to its previously-stated intention to sell all its mineral assets.

This deal reflects Cogema's on-going policy of seeking significant equity participation in existing or potential uranium production facilities in geographically diverse areas. Cogema already controls 1.25 percent of Energy Resources of Australia (ERA) directly, and another 2.5 percent indirectly through its 75-percent ownership of Interuran. In addition, Cogema holds a 15-percent share of Pancontinental Mining, which is now negotiating with ERA over the possible development of Pancontinental's rich Jabiluka uranium deposit, within a commercial framework that would be beneficial to all parties.

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RECENT DEVELOPMENTS

USA

Yucca Mountain Waste Repository

DOE made several small steps toward gaining access to the Yucca Mountain site in order to begin site characterization for the USA's first nuclear spent fuel repository. The Supreme Court let stand on March 4, a Ninth Circuit Court ruling requiring the state of Nevada to review permit applications for environmental assessment of the site. Nevada said it will begin processing the first three (of 18 required) environmental permits for dust, ground water, and underground injection control for water studies. Normal processing of these permits takes three to nine months, but according to DOE's waste program Director John Bartlett, Nevada could extend the process from two to eight years if they want to stall further. As part of the National Energy Strategy (NES), the administration took the first step to remove the state's authority to review these permits. A section of the NES will amend the Nuclear Waste Policy Act of 1982 to make it possible for DOE to conduct site characterization studies without permits from a state government. Nevada's politicians are very vocal in their opposition to DOE and Congress' attempt to override the State's rights. At a Senate Energy and Natural Resources Committee hearing on the waste program March 21, DOE Secretary James Watkins and Committee Chairman J. Bennett Johnston asked Nevada Governor Bob Miller to cooperate with the federal government's efforts to characterize the site. Watkins testified that Nevada's "scorched-earth battle plan" will leave Congress with no other alternative than to pass a bill resolving the impasse at Yucca Mountain. Governor Miller testified that although the state's litigation has contributed to delays in the program, the primary reason for the lack of progress is the lack of a qualified quality assurance program, and incomplete information required for environmental permits for the on-site study. Gov. Miller and the other state officials' testimony indicated they will continue to oppose siting the repository until they are confident DOE's program will protect the health and safety of Nevada residents. Congress has signalled its intent to solve the matter legislatively. Utility witness, Allen J. Keesler, Jr., President and CEO of Florida Power Corporation, testified in support of Congressional efforts, saying "continuing to demonstrate real progress toward developing a repository is critical to restoring public confidence in nuclear energy."

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USCEA

Fuel Cycle '91 Conference

The US Council for Energy Awareness (USCEA) Fuel Cycle '91 Conference in Scottsdale, Arizona, held March 24-28, provided the forum for discussing the nuclear option as part of the National Energy Strategy as well as examining anticipated changes that will affect the nuclear industry in the 1990s. In particular, a panel discussed the globalization of the nuclear fuel market and the effect this market has on fuel manager purchasing decisions. During the conference, Harold B. Finger presented his final paper as President and CEO of the USCEA. After a little over eight years, Mr. Finger will be retiring from USCEA on May 1. His successor will be Mr. J. Phillip Bayne, President and CEO of the New York Power Authority. The following are summaries of some selected papers presented at the conference.

Nuclear Energy's Role in the National Energy Strategy

DOE's Assistant Secretary for Nuclear Energy, William H. Young, spoke briefly on the extensive process involved in preparing the National Energy Strategy (NES) and how nuclear power can contribute to meeting the nation's growing demand for electricity. The increase in demand will result in a need for 200 GWe of additional generating capacity from all types of power plants. Nuclear power can meet some of this demand, and DOE will be working in several areas to support these efforts. By 1993, DOE will submit a plan to extend the life of current nuclear power plants from 40 to 60 years, and is expected to have completed development of the advanced liquid metal reactor by 1995. Mr. Young stressed the importance of standardization of reactor design and licensing reform in the NES, and asserted the need to move DOE's uranium enrichment program to the private sector.

A Public Service Commissioner's Perspective on the National Energy Strategy

Commissioner Michael M. Wilson of the Florida Public Service Commission stated that Florida will need 15 GWe of additional electric generating capacity by 2010 after conservation is taken into account. The mix of technology used to meet this demand must be a balanced portfolio providing a diverse set of generation alternatives given environmental and economic concerns. He felt that the National Energy Strategy falls short in energy efficiency and conservation, and that there should be greater encouragement for states to be more involved in local energy strategy. Mr. Wilson believes at this time that nuclear power is not a viable option for electrical generating needs. Legislative action is necessary to address economic and regulatory concerns, the waste disposal issue, elimination of the uranium enrichment debt, and licensing reform. When questioned on what position a PUC should take on the purchase of domestic uranium as opposed to foreign origin uranium, Mr. Wilson stressed the importance of having a mix of sources, and that a balanced mix would minimize risk.

The Strategic Plan for Building New Nuclear Power Plants

Uncertainty remains a prime characteristic of the electric utility business according to Harold B. Finger, President and CEO of the USCEA. A strategic plan developed by the Nuclear Power Oversight Committee, addresses the issues confronting the nuclear industry, assigns responsibility, and sets timetables and milestones to create the conditions under which utilities can place a new nuclear plant order by the mid-1990s. Some issues, such as improving the performance of operating plants, are within the industry's direct control. Other issues, such as securing approval and acceptance for sites, require actions at the state and federal level. Mr. Finger believes that overcoming the difficulties of implementing this plan will not be easy, but the payoff to industry and the country is too great even to consider the possibility of failure.

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Energy Outlook for Europe

Mr. Stig Sandklef of Vattenfall Fuel (Sweden), characterized European energy consumption as relying on relatively high levels of fuel imports, especially natural gas, uranium, and coal. Nuclear power development will play a limited role in Europe for the next 20 years, due to institutional factors, public opinion, capital requirements, and long lead times. The Soviet Union is the largest energy producer in the world and has enormous reserves of fuel, which provides a strong incentive for Europe to promote stability in the Soviet Union and perhaps create a long-term trade relationship. A large stockpile of Soviet natural uranium and excess enrichment capacity will play an important role in keeping present spot market prices low, even if the material is not sold.

Uranium Supply and Demand Trends

Jeffrey Combs of Science Applications International Corporation, contends that low spot prices are not just the result of the massive supplies available. He believes a reduction in demand due to changes in utility inventory policies and the special selling circumstances of suppliers have also affected prices. Spot demand appears poised to increase significantly, but its extent will be a function of future spot price levels. Since the transition of the Soviet Union into a market economy will be slow, uranium will remain as one of the primary hard currency earners for the Soviets, thereby reducing the chances for uranium prices to recover in the near term. Mr. Combs believes that eventually a more competive economic system will lead to a return to a market more closely related to that of the 1970s than of the late 1980s.

Navigating the Nuclear Trade Winds: Charting a Course for the 1990s

James A. Glasgow of Muntzing and Glasgow discussed the current and potential legislative efforts that involve restricting the use of non-US uranium. Among the items he addressed were the voluntary overfeeding program that would require domestic uranium; Senator Wallop's draft bill requiring US utilities to use domestic uranium for two-thirds of their requirements; national security exceptions; bilateral nuclear cooperation agreements; and the trend toward reciprocal contracts. Mr. Glasgow feels that US participants in nuclear commerce appear to give only sporadic attention to the international institutions and bilateral agreements upon which their commerce depends. Areas such as proposed legislation, renegotiations of bilateral cooperations agreements, extension of the NPT, and other actions are important to the future of international commerce at the front and back ends of the nuclear fuel cycle, and industry participants should make an effort to identify areas where collective efforts are needed.

DOE Enrichment Update

The Uranium Enrichment Enterprise (UEE) is a vital part of the National Energy Strategy, asserted Philip G. Sewell, DOE's Deputy Assistant Secretary for Uranium Enrichment. He contends that the question is not whether the UEE is needed, but how it can best meet the needs of the nuclear industry. Mr. Sewell summarized the points that were reaffirmed by the Smith Barney study: with restructuring UEE can be more competitive, more reactive to market forces, deploy advanced technologies on an economic basis, and can exhibit a strong financial position by minimizing delays and maximizing market value. He stated that DOE's world market share is about 50 percent in 1991, and decreases to less that 30 percent by 1999. In addition, DOE was devoting particular attention to Soviet marketing practices in the USA and all sales with regard to fair trade practices. In response to a question of how AVLIS will be transferred, since deployment funds are not provided for in the FY 1992 budget request, Mr. Sewell stated that a restructured corporation will take R&D technology to the market more efficiently, and it is expected that the corporation will provide funds at the appropriate time.

Regulatory Implications for the Future of Nuclear Power

Robert W. Bishop of the Nuclear Management and Resources Council, reviewed the political issues and processes that seem to overwhelm the industry's ability to provide technical solutions to problems. It has been the tendency of regulatory agencies to address problems by adopting additional regulations, rather than focusing on the quality of regulatory activities. Standard design certification/combined licenses, and license renewal for reactors exceeding their 40-year term, are two major issues that are being addressed by the industry and the NRC to improve the regulatory process. Mr. Bishop believes that the industry can support these issues by ensuring that facilities operate properly, safely, and economically.

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The Economics of the Nuclear Fuel Cycle: What Makes a Fuel Manager's World Go Round?

John J. Stobbs of Nuclear Assurance Corporation (NAC) moderated a panel that addressed several questions involving the globalization of the nuclear fuel market. The global marketplace can offer utilities cheaper prices and diversification, but potential risks exist, including possible supply interruptions, or protectionism stemming from high import levels that have affected domestic programs. Though national security considerations are less a of concern to a utility than supply security, reliance on foreign supplies can reduce a country's ability to maintain its own sources and supply its own needs.

From a utility point of view, regulatory actions are less important in fuel purchase decisions than being competitive and keeping cost at the lowest level possible, while still maintaining reliability. A PUC panel member emphasized that regulatory actions encourage utilities to be more competitive, by establishing procedures and policies that make utilities perform rigorous analysis, with sound recommendations, and proper documentation and justification. In response to a question, Evan C. Rowe of the Public Utility Commission of Texas thought that a typical, acceptable utility contracting strategy would include a five-reload contract with a fuel fabricator, three different U_3O_8 suppliers, and one conversion services supplier.

Overview of Fuel Management Analysis

Julian J. Steyn of Energy Resources International examined utility procurement strategy development for the 1990s. Unlike the situation that existed in the 1980s, US utilities in the 1990s can obtain a range of services and uranium in a relatively free world marketplace with diverse and competitive sources. Utilities must now decide on an appropriate mix of spot market and long-term contracts; the choice will be related, in part, to the quantity flexibility and pricing terms offered in term contracts. To take advantage of these market changes, Mr. Steyn suggests that utilities develop a set of primary objectives as part of a procurement policy against which key fuel procurement decision alternatives may be evaluated. These objectives can be useful in developing a strategy to optimize procurement decisions, by providing a systematic approach that provides a basis for future internal policy reassessments, and substantiates the decision-making process in response to public service commission audits.

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RECENT DEVELOPMENTS

WASHINGTON FOCUS

by Linda L. Gunter

Energy and the federal budget remained top agenda items within Congress in March. Energy Secretary Watkins testified before energy committees of both bodies of Congress on the Administration's National Energy Strategy (NES); the strategy was transmitted to Congress on March 6 as bills S 570 & HR 1301. Several Congressmen also have introduced energy legislation, including the National Energy Efficiency Act (S 741) sponsored by Sen. Tim Wirth (D-CO), and the Comprehensive Energy Strategy Act of 1991 (HR 1543) sponsored by the House Republican energy caucus which expands on the NES. President Bush is expected to issue an executive order which will require 20 percent cuts in energy consumption in all federal agencies by the year 2000. DOE testified in March before the House Appropriations subcommittee on Energy about the uranium enrichment program's budget. The Senate Energy & Natural Resources Committee held a hearing early in the month to consider DOE's request to purchase, rather than produce, SWU, and also to consider the effect of Soviet material entering the market.

DOE Considers SWU Purchase

◇ On March 7, DOE Assistant Secretary for Nuclear Energy, William Young, testified before the House Appropriations Subcommittee on Energy & Power. Most of the testimony was devoted to DOE's budget for its waste clean up program, and advanced reactor funding. However, Mr. Young was also questioned about DOE's decision to purchase, rather than produce SWU, as long as the purchase price is below DOE's cost of production. Young said the emergence of the Soviet Union as a long-term supplier "represents a serious market threat that should be addressed promptly." While asking Congress to again consider restructuring legislation, DOE has taken initial steps to be competitive in the future. Young said DOE has begun to make offers in the 1996-1998 period that "in a free market with fair trade practices, ...will be attractive to potential customers..." DOE is projecting net revenue of $159 million in FY 92, up from $110 million in FY 91. Although DOE will increase spending on environmental corrective actions by 36 percent over FY 91, lower-priced power costs will offset this anticipated increase.

Enrichment Legislation

◇ The Senate Energy & Natural Resources Committee held a hearing on Sen. Wendell Ford's enrichment restructuring bill (S 210) on March 7. DOE Deputy Secretary Henson Moore, and Nick Timbers, Managing Director from Smith Barney Harris Upham & Co., Inc., were the two principle witnesses. DOE testified of its urgent need to restructure because of growing competition in the market. If Congress does not pass legislation to allow DOE to become more competitive, DOE may lose its commercial customers, and the taxpayer would then incur an additional $300 million in added costs for servicing military SWU requirements. Sen. Malcom Wallop (R-WY) asked if the Soviets were dumping SWU. DOE is studying the Soviets' presence in the market and plans to have a report finished by April 15.

Proposed Legislation to Limit Affect of Soviet Uranium Imports

◇ Sen. Wallop revealed that he is considering legislation which will help the domestic uranium industry and start an investigation into Soviet uranium marketing practices. The draft bill calls for a study to determine if the Soviets are dumping natural and enriched uranium. A key section of the bill would require,

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after 1995, that all civilian reactor owners purchase at least two-thirds of their fuel materials from US sources. The bill would require an annual report from reactor operators on the origin of the uranium and EUP in their reactors, but would protect a utility from PUC oversight of its uranium procurement if the utility purchased US origin material. DOE was asked for its comments on the bill but has not yet responded. Industry is concerned because the obvious anti-free trade elements of the bill, especially with regard to possible illegality under GATT and the US-Canada Free Trade Agreement. In addition, if this bill becomes an amendment to the enrichment restructuring bill S 210, it could create more problems and delay Senate passage of restructuring legislation.

Fernald Material

◇ Sen. Pete Domenici (R-NM) agreed with Sen. Wallop that foreign uranium imports are a problem for the mining industry, but indicated he was more concerned about what the US government has done to injure the industry. He referred to recent news reports that DOE plans to sell fuel scraps from Fernald and Hanford from the weapons program. Moore agreed to look into the issue, and consult with the committee prior to any sale which could have an adverse affect on the domestic uranium industry.

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RECENT DEVELOPMENTS

INDUSTRY BRIEFS

Hungary to Continue to Use Soviet Fuel Cycle Services

The management of Hungary's Paks Nuclear Power Station reached an agreement with Atomenergoexport of the Soviet Union for the purchase of fabricated fuel for use in Paks' four VVER-440 units. A major factor in the choice of Atomenergoexport was that the Paks station's spent fuel will likely be taken by Atomenergoexport for final disposal in the Soviet Union. The contract covers the entire operational life of the Paks units. Paks' management sought competing western offers, but no other offer contained a provision for the final disposal of spent fuel. Unlike prior fuel supply contracts with Atomenergoexport, the contract requires that Atomenergoexport be paid in hard currency, not in transfer rubles; payments will be negotiated annually.

In a separate contract, the Soviet Union agreed to purchase the yellowcake needed to produce the Paks fuel from the Mecsek mine (now a Hungarian-Irish joint venture; Monthly Report #268, Dec. 1990, p.19), at a price that can be evaluated as equivalent to world market prices.

Denison Temporarily Suspends Elliot Lake Operations

Denison Mines Ltd. announced that operations at its Elliot Lake uranium production facility have been suspended for six weeks, as of March 15. On June 28, another 400 jobs will be cut from the remaining work force of 1,060 people, and operations will again be suspended, this time for a seven–week period, during which time maintenance work will be performed.

These measures are being taken to reduce costs, while decreasing mine production to a level equivalent to Denison's delivery commitments to Ontario Hydro (1.4 million pounds U_3O_8 per year). Due to high production costs, Denison cannot profitably supply Tokyo Electric Power Corporation (TEPCO) under its existing sales agreement. Denison plans to fulfill its delivery obligations to TEPCO utilizing U_3O_8 produced from the recently formed joint-venture with Freeport-McMoRan.

German Ruling Party Supports New PWRs in Former GDR

The German coalition government, in particular, the ruling Christian Democrat Union, announced its support of a plan to build two new 1,300-MWe PWRs by 1996. Both units would be located in eastern Germany—one at the Greifswald site located in the state of Mecklenburg-Vorpommern, and one at the Stendal in the state of Saxony-Anhalt. Premiers of both these states have said they will support utility investments for the construction of the new nuclear plants. Much of the support of the plan comes from those groups that want Germany, particularly eastern Germany, to achieve an improved mix of fuel sources for electricity generation. With the closing in the past year of all of the former East Germany's Soviet-designed reactors, eastern Germany now uses lignite coal to fuel nearly all of its electricity generation.

However, the opposing Social Democratic Party (SDP) has vowed to prevent construction of the reactors, and German utilities are reluctant to begin new nuclear plant construction without full assurances from German authorities that the plants would be completed.

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JAERI Breaks Ground On High Temperature Test Reactor

On March 15, the Japan Atomic Energy Research Institute (JAERI) broke ground for a ¥80 billion (approximately US$615 million) High Temperature Engineering Test Reactor (HTTR) at its Oarai Research Establishment. The reactor is scheduled to achieve criticality in 1995-1996.

The 30 gigawatt (thermal) reactor will utilize specially-fabricated uranium-dioxide (UO_2) fuel, mixed in various enrichments ranging from 3 w/o to 10 w/o ^{235}U, and placed in a graphite reactor core. JAERI expects the primary coolant (helium) temperature to attain a maximum value of 950°C at the reactor exit, nearly triple the typical exit temperature of current light water reactors.

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DOE Awards NPR Construction Management Contracts

DOE has awarded two construction management contracts (each worth up to $4 million) for the first US New Production Reactor (NPR). Winners of the contracts are Bechtel National Inc., for a heavy water reactor at the Savannah River site, and Fluor Daniel, for a modular high-temperature, gas-cooled reactor (MHTGR) at the Idaho National Engineering Laboratory. Late this year, DOE will select which technology it will pursue through to the completion of a demonstration plant.

Swiss Government Supports Increase in Nuclear Plant Capacities

Swiss government officials recently announced their support of a plan to increase generating capacities of the country's nuclear power plants by at least ten percent by the year 2000. On September 23, 1990, Swiss voters passed a referendum that imposed a 10-year moratorium on all nuclear power plant licensing and construction. Therefore, increasing unit capacities is the only current option available for nuclear power to contribute to the nation's growth in generating capacity. Swiss utilities had proposed the capacity increases (ranging from 10 to 15 percent per unit) in May 1990, when substantial public opposition to construction of a sixth nuclear plant was already evident (Monthly Report #262, June 1990, p.20).

German State Issues Siemens MOX Plant License Before Greens Take Office

On March 12, in an action clearly timed to beat the incoming anti-nuclear party's taking of office, the Minister of Environment for the German State of Hesse, Karl-Heinz Weimar, issued Seimens a definitive license for the company to operate its mixed-oxide fuel production facility in Hanau. Operation of the plant is opposed by the incoming coalition of the Social Democratic Party (SDP) and the Green Party, who took office on April 5 after achieving a narrow victory in January 20, 1991 state elections. Environmental Minister Weimar recognized that the incoming government would attempt to stop MOX production with challenges to the license, so he attached a rider to Siemens' license which allows the plant to remain in operation pending resolution of any legal challenges.

Licensing of the MOX facility concludes a 15-year relicensing process of all of Germany's fuel cycle facilities, following a 1975 revision to the German Atomic Act. The revision required all fuel cycle facilities license approvals to be based upon the same criteria applied to nuclear power plants. Issuance of the license opens the option for plutonium, previously shipped to France and the UK for reprocessing, to be returned for MOX fuel production in Germany.

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RÖSSING URANIUM LIMITED

The government of Namibia, celebrating the first anniversary (March 21) of the country's independence from South African rule, is looking to Rössing Uranium Limited (RUL) to improve the economic health of the country. RUL is Namibia's largest employer, producer of one third of the country's exports and 13 percent of its domestic product. The Rössing mine is the second largest uranium mine in the world, producing over 108 million pounds U_3O_8 from 1976 through 1989, and still holding an estimated 322 million pounds in reserves. Yet Rössing is one of the lowest grade uranium deposits ever commercially exploited, with an average grade of only 0.035 %U_3O_8. To efficiently develop such a low-grade deposit, RUL uses extensive real-time cost analysis systems and has the highest rock production rate (ore plus waste) of any uranium mine in the world, over 300 thousand tons per day.

History

Prospectors working in a remote part of Africa's Namib Desert, near Rössing Mountain in Namibia, first discovered uranium in 1910. In 1928, Captain P. Louw and his wife Margery, discovered a heavy, black mineral at a site about 20 kilometers west of today's Rössing mine, and confirmed its radioactivity. Sporadic prospecting throughout the concession area into the 1940s resulted in the discoveries of widely-disseminated uranium-bearing rocks.

In 1955, the Louw Syndicate was formed to once again locate Captain Louw's original find. In 1954, when the find was located, the Louw Syndicate obtained a prospecting grant for the concession area. A short time later, Anglo American Prospecting Company of South Africa secured a two-year prospecting and option agreement with the Louw Syndicate, for the investigation of the commercial potential of the 1,200 square mile concession area. During this investigation, the first concerted action toward geologic assessment of the area, Anglo American identified a number of radioactive anomalies. During the evaluation process, geologists delineated highly-disseminated mineralization averaging approximately 0.035 %U_3O_8. However, Anglo American let the option period expire without taking any further action. In 1965, the concession area was reduced to 400 square miles.

In 1966, RTZ expressed an interest in the Namib property. RTZ Corporation plc (formerly Rio Tinto Zinc Corporation plc), is a British corporation originally formed in the 1800s to exploit copper deposits in Spain. RTZ has since grown into one of the world's largest mining companies with major interests in copper, borax, iron, aluminium, and uranium. RTZ's uranium interests include mines and deposits in Australia, Canada, Namibia, South Africa, and the USA. RTZ had declined participation in development efforts on two previous occasions. The renewed interest of RTZ was attributable to two promising developments:

- Emerging long-term uranium marketing opportunities;
- Improvements in large-scale mining and mineral recovery technology.

RTZ assigned its South African subsidiary, Rio Tinto South Africa Ltd., to perform an evaluation of the property. Following favorable results of the evaluation, RTZ negotiated a six-year option with the Louw Syndicate, and set out to perform geological studies. In 1970, following further favorable results from varied testing, RTZ created a subsidiary, Rössing Uranium Limited, to operate the project. The project's mill, built on site, produced its first U_3O_8 in mid–1976. Though initially hampered by numerous problems, production did reach a rate of 10 million pounds U_3O_8 per year by 1979—a production rate second only to that of the Canadian Key Lake project.

Capital Costs

By mid-1976, RUL had invested US$350 million for the initial capital costs of the Rössing project. An additional $35 million has been invested over the past three years in order to achieve the full-rated capacity of the plant; 16.5 million tons of ore per year.

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Ownership

Namibia became an independent nation on March 21, 1990, via a United Nations' negotiated settlement for the release of Namibia from 70 years of South African control. Following its independence, Namibia's new government has a majority voting interest (51%) in RUL, although the government holds only a 3.4% ownership interest (since 1987, and held through Capricorn Trust). In the mid-1970s, RTZ sold shares in RUL to a diverse group of mining and investment companies. Holders of the beneficial interests in Rössing Uranium Ltd. are shown in **Table 1**.

Table 1
BENEFICIAL INTERESTS IN RÖSSING URANIUM LIMITED

Company	Country	Share
The RTZ Corporation plc[1]	UK	41.4%
Industrial Development Corp.	South Africa	10.0%
Total Compagnie Minière	France	10.0%
Rio Algom Ltd.[1]	Canada	10.0%
Urangesellschaft GmbH	Germany	5.0%
Capricorn Trust[2]	Namibia	3.4%
General Mining Corp.	South Africa	2.3%
Undisclosed[3]	—	17.9%

[1] RTZ owns 51.3% of Rio Algom, so RTZ's net beneficial interest in Rössing is 46.5%.

[2] The Capricorn Trust was established in 1987 to hold and manage Namibia's share in Rössing. Dividend income is used for educational and other benefits for Namibia's people.

[3] 17.9% is held by several companies or national entities that participate under strict provisions of secrecy, and have therefore not been publicly disclosed.

Uranium Policy Considerations

With Namibia's new ruling party's assumption of office last year came considerable uncertainty about policies dealing with the mining industry. SWAPO (South West African People's Organization), the newly-elected ruling party, had indicated that nationalization of the mining industry might occur, despite a moderate pre-election position. An early policy document stated that mining projects might carry government ownership requirements in the future. The government was quick to comment that any ownership changes, should they occur, would be enacted gradually to avoid production disruptions.

The mining industry remains an attractive target for nationalization since it accounts for 80 percent of Namibia's exports, and more than one third of its domestic revenue. However, the new government does not want to discourage foreign investment. A study by the new government (completed in July 1990) recommended that the state should boost its earnings by increasing taxes on mining, rather than changing ownership.

In early February 1991, the current Director of Mining, Mr. K. Kapwanga, eased some concerns of the mining industry when he announced details of the soon-to-be-adopted Mines and Minerals Act–1991. Existing grants and other titles held under the terms of the current Mines, Works, and Minerals Ordinance of 1968 are to remain valid, and will remain so for at least three years. During those three years, conversions to equivalent rights available in the new act will be offered. Under the new act, medium and large-scale operators will be able to obtain a short-term reconnaissance license, with an initial term of three years, as well as a mining license that grants the exclusive right to mine exploitable minerals. Small-scale miners will be entitled to non-exclusive prospecting licenses. If market prices discourage short-term development, those holding exclusive prospecting licenses will have the option of applying for a mineral deposit retention license, which allows holding the property for later development. The initial term will be for five years, subject to regular review of the license holder's intentions.

Sales

RUL's production strategy is to produce to meet contracted deliveries. In 1989, production was about 80 percent of rated capacity, reflecting the expiration of most of the long-term supply contracts that were originally signed with utilities in the UK, France, Germany, Japan, Spain, Taiwan, and the USA, as well as the impact of US economic sanctions against South Africa and Namibia under the Comprehensive Anti-Apartheid Act of 1986.

RUL has future commitments under long-term contracts with utilities in Europe, Japan, Taiwan, and the USA. Since Namibia's independence, RTZ Mineral Services Ltd. (a wholly-owned subsidiary of RTZ Corp. that handles all sales of RUL uranium) has signed a supply contract with the French nuclear power generating industry for 10.4 million pounds of U_3O_8, for delivery during the period of 1995 to 2002. On March 21, 1991, coincidental with the one-year anniversary of Namibia's independence,

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RTZ Mineral Services announced in a press release the signing of RUL's first supply contract in the USA since Namibian independence. The buyer is Gulf States Utilities Company of Beaumont, Texas; RUL will supply up to 50 percent of Gulf States' requirements for the period 1991 through 1997.

RUL currently has negotiations underway with other potential customers, including several Japanese utilities. To promote these and other market opportunities, the Namibian government recently set up an office in Tokyo.

Namibia's introduction of its own monetary unit, the Namibian dollar, in 1993, may also have an effect on the competitive price of Namibian uranium in the future. One Namibian dollar will initially be set at parity with one South African Rand.

Location

The production center for the Rössing project is located in west-central Namibia, 23 kilometers inland from the Atlantic seaside town of Swakopmund, and 200 kilometers west of the city of Windhoek, Namibia's capital. The Rössing operations are situated at the northern edge of the Namib-Naukluft National Park. This park encompasses almost half of the Namib Desert, which extends along nearly the entire coast of the country in a 100-kilometer-wide strip, and is a vast area of sandy wastes, barren mountains, and sparse vegetation.

Geology

Current reserves at Rössing are estimated at 322 million pounds, at an average grade of 0.035 % U_3O_8. RUL is also performing exploration work in west-central Namibia, near Otjiwarongo and Spitzkoppe Mountain. Expenditures for exploratory drilling will exceed 3 million rands in 1991.

The Rössing uranium deposit occurs in rocks identified with the Damaran Orogeny, which has an estimated geologic age between 500 and 600 million years. The Damaran orogenic belt extends for several hundred miles in a northeast-southwest direction. It extends through Namibia (covering most of the Namib Desert region), northward into southern Angola, and possibly as far east as Zambia. The granitic intrusions and metamorphism characteristic of the Damaran orogenic belt are especially evident in an area around Rössing Mountain. It is within this area that the Rössing uranium deposit occurs.

The bulk of the economic mineralization is contained in the uranium-bearing intrusions of alaskite granite. Uraninite is the most important primary uranium mineral present in the deposit, constituting about 55 percent of the total uranium contained in the rock. The primary mineralization occurs in close association with concentrations of quartz, feldspar, and biotite, in the alaskite granite. The determined outline of mineralization measures approximately three kilometers long and one kilometer wide. Migration of uranium mineralization into normally barren country rock is a common occurrence, however, minable quantities rarely occur.

The origin of uranium minerals at Rössing is probably related to the emplacement of the granites in the area. The primary minerals were included as an integral part of the rock-forming process. The ore zones with high-grade concentrations probably developed as a result of segregation or banding that occurred in the early stages of consolidation (cooling) of the igneous rocks.

Mining

The Rössing project is an open-pit mine with reserves that are expected to last at least through 2020. The pit measured approximately three kilometers long, one kilometer wide, and 225 meters in depth (**Figure 1**) as of 1987. The ultimate depth will be approximately 330 meters. The Rössing mine produced 38,000 to 44,000 tons of ore per day during 1989. Based on a stripping ratio of three-to-one (waste-to-ore), total rock production was 160,000 to 176,000 tons per day.

According to RUL managing director Dr. Michael Bates' recent statements, RUL production would be cut by 21%, as of April 2, 1991, and remain at that level for three years. The production cuts are due to lagging sales, which Dr. Bates attributed to the remaining effects of past trade sanctions, world oversupply, and the influx of uranium from former East Bloc countries.

Despite the large daily tonnage, mining practice is selective to maintain both the uranium grade and the calcium index (a measure of the acid consumed during leaching) within predefined limits. Due to the complex nature of the mine, planners and grade control engineers have the responsibility of optimizing the operation. Computers are used extensively to determine the lowest-cost haul route, as well as the best metallurgical efficiency, to produce U_3O_8 at the lowest possible cost.

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Figure 1 – An elevated view of the Rössing mine, displaying the large 3 km deep, 1 km wide, and 225 m deep pit. The mine has the highest production (ore plus waste) of any uranium mine in the world.

Such a large scale and extensive operation requires the use of large-scale equipment. Major mining equipment includes:

- *Six–GD 120 blast hole drills.* Production holes are drilled 380mm in diameter. Blasting is done with a high-density mixture of Anfo with an emulsion (ammonium nitrate,waste oil, and an emulsifier).
- ***Eight**–P&H 2100 electric shovels* (11.5-cubic-yard buckets). Recently two Dresser model 201M 24-cubic-yard shovels have been added.
- ***Six**–Rubber-tired dozers;* three are Caterpillar model 82s, and three are Michigan model 280s.
- ***Twenty**–Wabco 170-ton diesel-electric haul trucks.* During 1986, eighteen trucks were converted to trolley-assist operation, to improve haulage speeds and lower fuel costs.

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Grade controllers examine the assays on every blast plan, and trucks are radiometrically scanned in order to determine an optimal mill feed. The scanned trucks are directed to waste dumps, low-grade stockpiles, high-calcium stockpiles, or primary crushers.

Milling

The mined ore is dumped directly into one of two 54-inch gyratory crushers, reduced to minus 160 mm, and then passed directly to a 440,000-ton capacity stockpile. Secondary crushing is done by two 84-inch Symons standard crushers, which reduce the ore to minus 65 mm. The ore is then screened at 19 mm, with the oversized ore then crushed in a tertiary crusher in closed circuit with the screen. The fine ore stockpile has a live capacity of 20,000 tons, and a total capacity of 88,000 tons. The capacity of the crushing plant is 2,750 tons per hour. The fine ore is further reduced to minus 1.7 mm in four parallel rod mills, each with a capacity of 550 tons per hour. Water is added to maintain pulp density.

The entire metallurgical operation is controlled by a centralized computer system. The rod mill discharge is first fed into the leaching circuit, where manganese dioxide is added to oxidize the uranium, then sulfuric acid is added to leach the uranium. The retention time in the leaching circuit is 13 hours.

The leached product is then separated, with the sand particles sent directly to the tailings pile, and the uranium-rich slimes are sent to a counter-current decantation (CCD) circuit for washing and separation. The separation produces a uranium-rich solution, and a thickener slime—the latter is sent directly to the tailings area.

The uranium-rich solution leaving the CCD is upgraded at an ion-exchange plant. The solution is next run through resin beads in a fluidized bed. The uranium-bearing resin beads are transferred to a fixed-bed system for elution with a 10% sulfuric acid solution. The acid eluate is transferred to the solvent extraction plant where this eluate is first mixed with an organic solvent, followed by an ammonium sulfate solution. Gaseous ammonia is added to precipitate the ammonium diurinate (yellowcake). The ammonium diurinate is washed, filtered, dried, and calcinated at 700°C, and then crushed and packaged for shipment.

Table 2
Rössing
Historical Uranium Production

Year	(1,000 pounds U_3O_8)
1976	1,544
1977	6,083
1978	7,012
1979	9,983
1980	10,508
1981	10,324
1982	9,817
1983	9,619
1984	9,600
1985	8,801
1986	9,026
1987	9,215
1988	9,127
1989	8,001
1990*	8,000
1991*	6,900
1992*	6,500

* Estimated

Conclusion

The Rössing operation remains one of the uranium industry's more interesting projects: very large but low-grade reserves; world's highest rock production rate; and a large-scale computerized production cost management system. The release of Namibia and its products from nearly four years of multi-national anti-apartheid sanctions offers Rössing Uranium Limited the opportunity to use its unusual assets to gain a position as a volume supplier to the world market. Managing Director Dr. Bates recently stated that RUL management has established good relationships with government officials, is encouraged by the attitude shown by the new Namibian government, and is optimistic about long-term market opportunities.

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CONVERSION AND ENRICHMENT IN THE SOVIET UNION

NUEXCO's November 1989 Report (No. 255, p. 21) presented an interview with Mr. Boris V. Nikipelov, First Deputy Minister of Atomic Energy and Industry (MAEI) in the USSR, in which Mr. Nikipelov discussed the technical and commercial activities of the Ministry. This article, summarizing conversion and enrichment in the Soviet Union, is based on information provided by Mr. Nikipelov and his colleague, Mr. Anatoly A. Vlasov, during a recent visit to the Soviet Union by Contributing Editor R. Wesley Miller. Although some technical and commercial details remain classified, the article contains much previously unavailable information, such as a conversion process flow chart and photographs of a gas centrifuge enrichment facility.

Introduction

In the Soviet Union, just as in the West, the civilian nuclear industry emerged from research work undertaken for nuclear weapons development. At first researchers tried various techniques for physical separation of uranium isotopes: electromagnetic and molecular-kinetic thermo-diffusion methods; gaseous diffusion; and centrifuge methods. All of those methods, which are based primarily on differences in the atomic mass of uranium isotopes, called for extensive research and the development of new, technically unprecedented equipment. Gradually gaseous diffusion and gas centrifuge technology became recognized as most feasible for industrial use, so research on other methods was terminated. Industrial-scale uranium enrichment in the Soviet Union began in 1949 using the gaseous diffusion method; by the early 1960s, centrifuge technology was in use on an industrial scale.

All Soviet production of highly-enriched, weapons-grade uranium was halted in 1987. The Soviet Union now has four enrichment plants in operation (at classified locations), solely for civilian nuclear power needs. All four enrichment plants have centrifuge modules, and enrichment provided by gaseous diffusion accounts for less than five percent of their total output. Two of the four enrichment plants also incorporate facilities for conversion to uranium hexafluoride (UF_6).

Conversion Technology Development

The Soviet Union began developing UF_6 conversion technology in 1947. Initially, this technology was based upon direct fluorination of mixed uranium oxide in single-tube horizontal reactors equipped with mixers, but it was inefficient compared to fluorination of uranium tetrafluoride (UF_4), a process that was being developed in parallel. That process was based on a sulfate system, which included the dissolving of U_3O_8 in sulfuric acid, the electrolytic regeneration of uranyl sulfate and, at the final stage, hydrofluorination. The fluorination of UF_4 used horizontal tube reactors which had a production capability of 1.0 to 1.2 tons per hour.

In 1956, the introduction of twin-tube fluorators improved the utilization of fluorine and increased production capacity to 2.5-8.0 tons UF_6 per hour. In 1965, the introduction of flame reactors (fluorination in dust infusions) made possible the fluorination of both UF_4 and uranium oxides. Design of the first generation of flame reactors included air-cooled retorts. Subsequently, water-cooled retorts were developed and introduced, thereby improving productivity.

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Current Conversion Technology

As shown in **Figure 1**, conversion of natural uranium oxides or UF_4 to solid UF_6 takes place in a balanced, continuous cycle that incorporates six principal steps.

- Pure anhydrous hydrogen fluoride (HF) is produced from the thermal decomposition of fluorspar (CaF_2) with sulfuric acid (H_2SO_4) in revolving, high-temperature furnaces. The final product, greater than 99.9% pure HF, is derived via fractional distillation.
- Elemental fluorine gas (F_2) is produced by the electrolytic decomposition of hydrogen fluoride in molten KF•2HF. A sufficiently high voltage causes electron transfers to occur at the electrodes in the following chemical reaction, which is carried out at 800°C to 1000°C.

$$2HF \xrightarrow[\text{molten KF•2HF}]{\text{electrolysis in}} H_2 + F_2$$

  This step uses high-output electrolyzers with carbon anodes that carry a current up to 20 kA and an electrolyte acidity of 36-39 percent. The service life of the electrolyzers (of the gas-separating bell, for example) is 7,500 hours; anode service life is up to 10,000 hours.
- Powdered natural uranium is fluorinated, with subsequent cooling of the reaction gases and filtration of solid impurities.
- Solid UF_6 is sublimed from the gas flow.
- Fluorine and uranium-bearing products are recovered from the gas flow of the primary uranium-bearing product stream.
- Liquid and gaseous by-products are neutralized.

The apparatus used for high-temperature single-stage fluorination includes a water-cooled vertical flame reactor, a reaction gas cooler that uses condensation-vaporization heat-exchange processes, and ceramic filters. Each unit has a capacity of 50 tons per day and is made primarily of nickel and monel-metal, resulting in a service life for the sub-assemblies (the reactor retort, mixer) of five years or more. The reaction gas cooler reduces temperatures from 600°-650°C (upon exiting the reaction zone) to 80°-100°C, extending the service life of ceramic filters and increasing the overall capacity of the direct fluorination process.

Gaseous Diffusion

The separation stage of a Soviet gaseous diffusion cascade consists of a cylindrical vessel enclosing two high-capacity compressors, several rows of fine, porous, tube-like filters, and two coolers. The compressors raise the gaseous UF_6 pressure to the required level. The coolers reduce the UF_6 temperature as it enters the separator after exiting the compressor. Under a vacuum, the lighter UF_6 molecules ($^{235}UF_6$) pass through the pores faster than the heavier UF_6 molecules ($^{238}UF_6$) so that the gas that passes through the filter becomes slightly enriched (weight-percent of ^{235}U isotope greater than its natural fraction of 0.711%) while the remaining gas becomes slightly depleted (in ^{235}U). This process is repeated many times through connected separation stages to achieve the cascade effect. (Each pass through a filter constitutes one stage.) This gaseous diffusion cascade consists of over 1,000 stages, each of which is driven by a powerful compressor. Practically all the energy consumed by the gaseous diffusion process is given off as heat, which must then be drained off using temperature-controlled water (to avoid the thermal shock that could be caused by using water with too low a temperature). Electricity accounts for nearly half of the total operating cost of a gaseous diffusion enrichment plant. Thus, a high consumption of electricity remains both the defining characteristic and the greatest shortcoming of gaseous diffusion technology for uranium enrichment.

The first gaseous diffusion uranium enrichment plant in the USSR started operating in the Urals (near Sverdlovsk) in 1949, but it was relatively inefficient. During its first four years, researchers did a large amount of development work for subsequent application to industrial equipment and technologies. The most critical technical issue was the design of a compressor that could achieve the required throughput and degree of compression. In the development of such a compressor, uranium hexafluoride's unique aerodynamic qualities presented problems that could not be resolved by experimentation with ordinary gases. A radial (centrifugal) compressor design was chosen for various reasons, including limitations on Soviet machine-tool capabilities at the time. A rather simple design, it was significantly less efficient than the axial, multistage compressors used by France and the USA.

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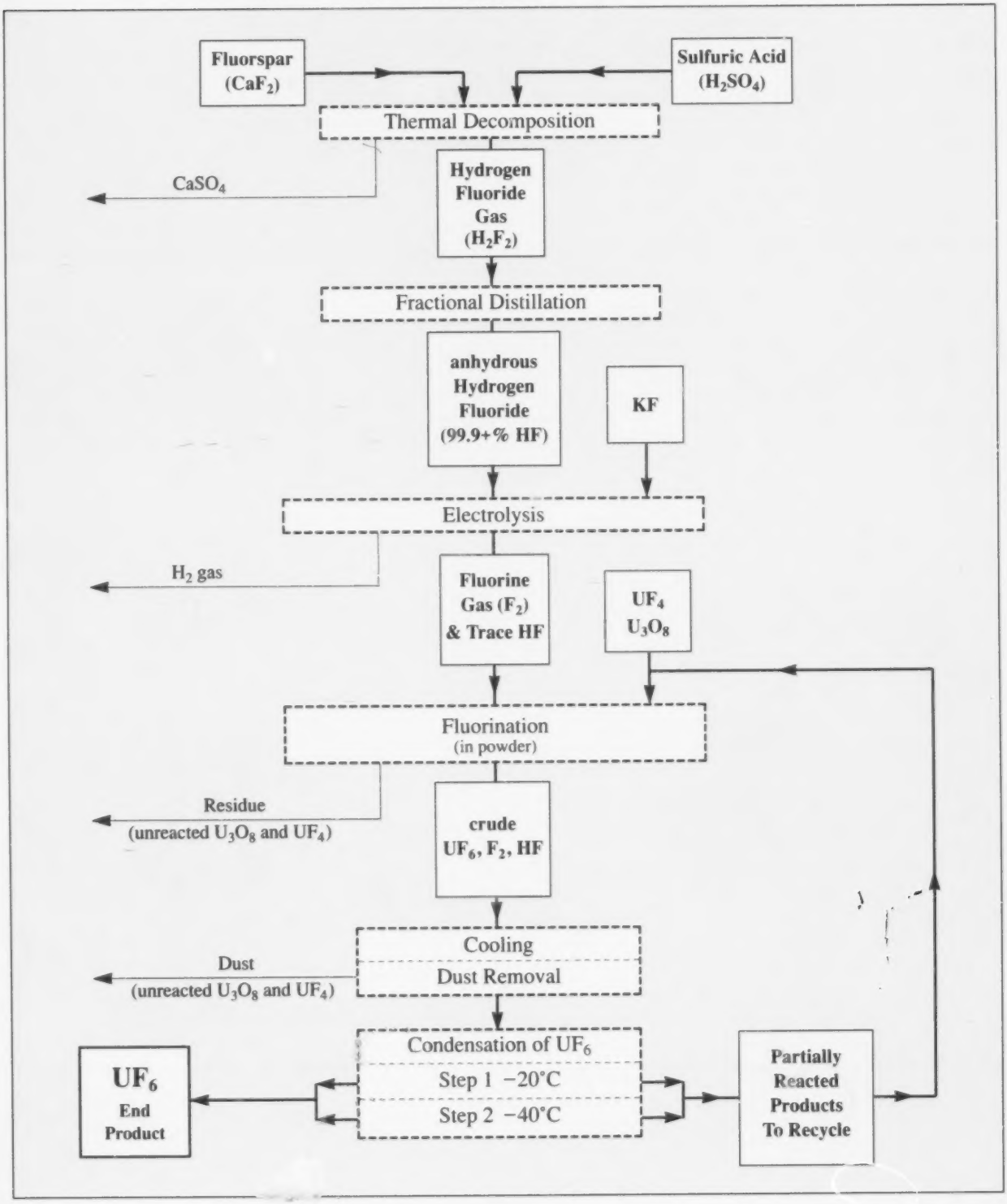
Figure 1
SOVIET CONVERSION PROCESS FLOW DIAGRAM



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Radial compressors were also used in later Soviet gaseous diffusion plants. **Figure 2** and **Figure 3** show interior views of a retired gaseous diffusion plant formerly used for weapons purposes. The inefficiency of radial compressors was one of the primary factors motivating the Soviet Union's intensive development work on gas centrifuge enrichment in the early 1950s.

The gaseous diffusion plants operated reliably, with repair intervals of seven to nine years. Air intrusion to the interior of the compressor along the rotating shaft was prevented by using precision seals with long service lives. The primary cause of unscheduled shut-downs was insufficient reliability of the compressor unit and electrodrive bearings.

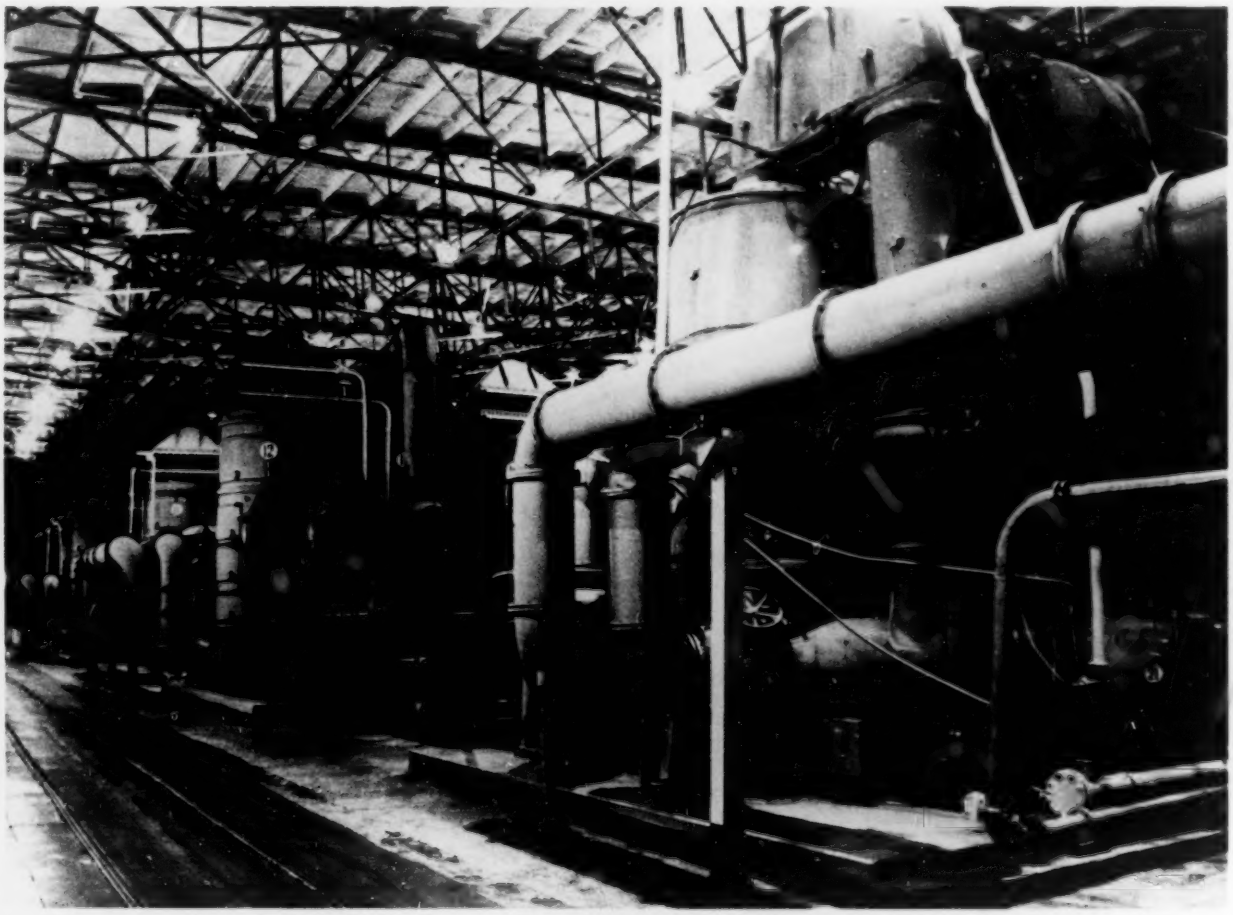

Figure 2 – Interior view (first of two; see also Figure 3) of a retired gaseous diffusion plant, formerly used for weapons production. *(Photo Courtesy of MAEI).*

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The development of effective isolation filters was the primary and most complex problem of gaseous diffusion technology. Without effective seals to maintain the required high vacuum, effective filter operation, both in the separation cascade and the cascade as a whole, is impossible. However, when gaseous diffusion technology was first introduced, vacuum technology was just in its infancy. The country's first leak detector with a sensitivity meeting operational requirements (24 μm Hg per day) was developed specifically to solve that problem. This instrument, a mass spectrometer which is fed a mixture of helium and nitrogen, had sufficient sensitivity, required minimal care, and reacted quickly—characteristics especially important in checking the tightness of large vessels.

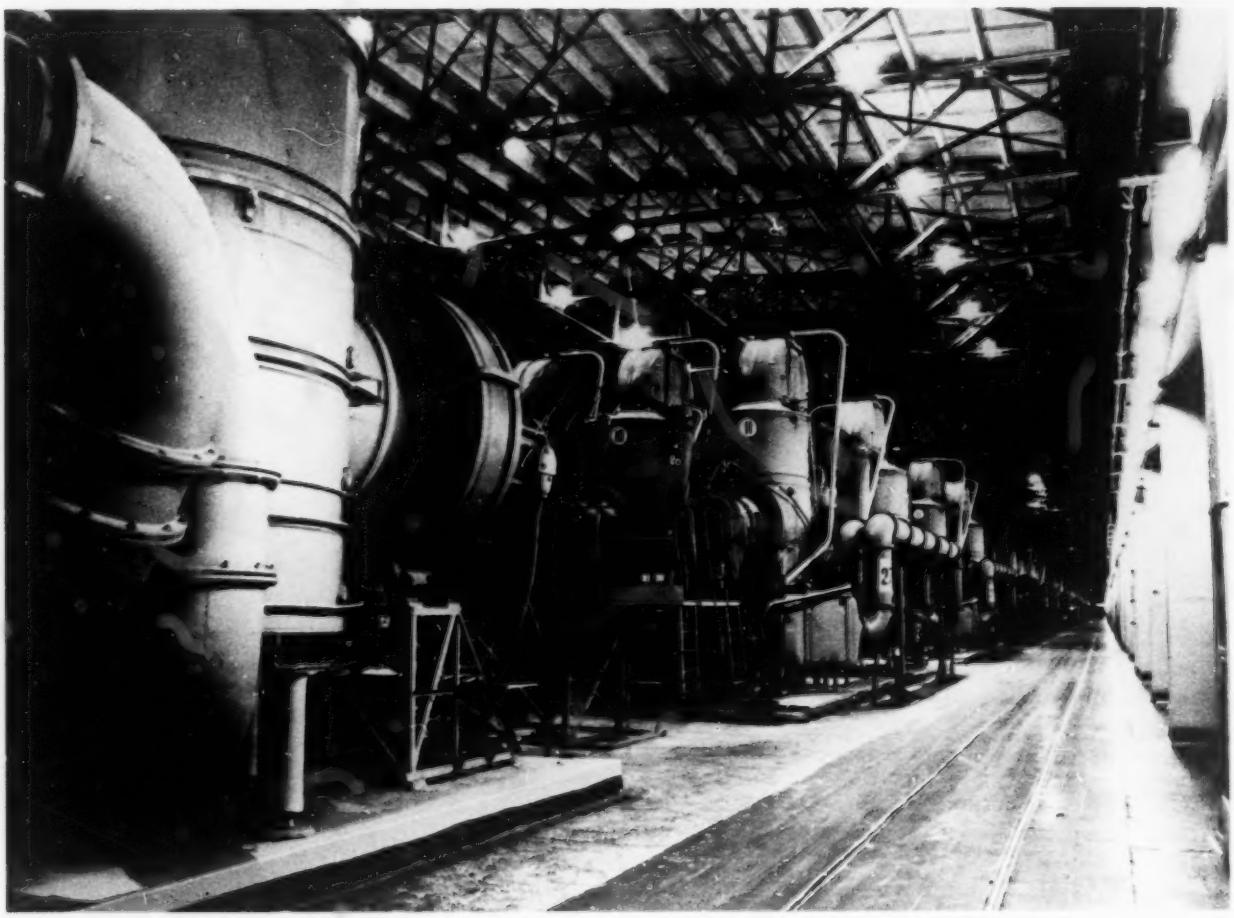

Figure 3 – Interior view (second of two; see also Figure 2) of a retired gaseous diffusion plant, formerly used for weapons production. *(Photo Courtesy of MAEI).*

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Filters used in the gaseous diffusion process must have a number of special qualities.

- The dividing layer (of 0.01 mm thickness) must have a uniform, high degree of porosity (average radius $^{1}/_{100}{}^{th}$ of a micrometer).
- The filters must maintain their separating capability for several years of operation in the highly-corrosive uranium hexafluoride environment.
- The mechanical strength of filters must allow operation for extended periods under conditions of fluctuating pressure and vibration.

The technology for manufacturing a nickel separating filter is based on methods of powder metallurgy (preparation of powders, rolling and sintering, application of the separating layer, and so on). A filter is made with two layers, one carrier and one separating layer. Made primarily of nickel, the separating filter is a tubular structure 550 mm long and 15 mm in diameter, with a thickness less than 0.1 mm. Operating experience has shown that such filters are highly effective for the gaseous diffusion stage design adopted, have good separation characteristics, and can operate without reconditioning for over ten years. On the whole, the technology introduced for making separating filters exhibited good flexibility, since it permitted constant improvement of the filters themselves without overall redesign.

Gas Centrifuge Technology

The fundamental advantage of the gas centrifuge method over gaseous diffusion arises from the fact that the primary isotope separation effect occurs at thermodynamic equilibrium. Thus, gas centrifuge enrichment uses only about $^{1}/_{20}{}^{th}$ to $^{1}/_{30}{}^{th}$ of the electricity per SWU required by gaseous diffusion. The plant can be built with the right number of centrifuges to bring it close to its ideal cascade size with almost no separative work losses. Lastly, gas centrifuges require low working inventories of UF_6, which ensures a high degree of production flexibility, such as when altering the cascade for a different final product or tails assay.

A Soviet gas centrifuge utilizes a rotor turning at high speed in a vacuum chamber (pressure 10^{-4} to 10^{-5} mm Hg). The rotor contains gaseous UF_6. The action of centrifugal forces causes a partial separation of isotopes along the radial axis: near the rotor axis, an excited layer of gas is enriched in light $^{235}UF_6$ molecules; at the periphery an excited layer of gas is slightly depleted (in $^{235}UF_6$ molecules). The axial counterflow motion of these two excited layers of gas converts the initial radial isotope separation effect into an axial one, enabling that effect to be multiplied. The two layers of gas—enriched and depleted—are removed from the rotor face through a series of tubes. (For separation in the rotor, gas is fed in through a separate tube.)

In a gas centrifuge, the initial equilibrium separation ratio depends on the absolute difference between the molecular weights of the isotopes and on the linear speed of rotation. The centrifuge's separative capacity is directly proportional to the length of the rotor and the fourth power of its linear speed of rotation. On the other hand, the speed is limited by allowable mechanical stresses in the structural materials of the centrifuge rotor. Increasing its length involves solving the complex technical problem of creating a supercritical rotor, one that rotates at a frequency exceeding the critical frequency of intrinsic bending vibrations. For these reasons, a single gas centrifuge cannot achieve the desired enrichment. However, a Soviet gas centrifuge enrichment cascade contains only ten to twelve successive stages, rather than the thousand or more stages required by gaseous diffusion. Each stage has a large number of parallel gas centrifuges.

The design of the Soviet gas centrifuge for uranium isotope separation includes six basic assemblies and elements:

- a vertical metal thin-walled cylindrical rotor reinforced with composite material;
- a magnetic mount that confines the rotor in the vertical position and prevents the top from vibrating relative to the rotor axis;
- a needle bearing and an oil dampener to absorb the energy of rotor vibrations, both during startup and during operation at rated speeds, despite various types of mechanical and hydraulic perturbations;
- a disk-type synchronous hysteresis motor running on three-phase AC;
- a steel housing for the centrifuge, which provides high vacuum during rotor rotation. The top of the housing includes molecular pumps in the form of fixed bushings with helical slots coaxial to the rotor, with a small gap. The surface of the housing is water-cooled;
- a gas distribution manifold fastened to the machine's top cover, through whose lines gas is supplied to the rotor and the light and heavy fractions are removed.

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Gas centrifuges require no special preventive maintenance throughout their entire service lives, and the machines' separation characteristics remain practically constant over time.

Commercialization of Gas Centrifuge Technology

The commercialization of Soviet gas centrifuge technology for uranium enrichment required the solving of a broad range of complex scientific and engineering problems in most diverse areas: metallurgy and materials science; mechanical engineering; ultrahigh-speed tubular rotor dynamics and strength mechanics; gas dynamics and the physics of separation processes; physical chemistry; and more. On October 4, 1957, again in Sverdlovsk province, the first Soviet pilot (demonstration) plant was commissioned; it contained 2,500 gas centrifuges. This plant tested both the first industrial-design centrifuges and the new support systems (electric power supply, monitoring, automation, and control) that had to be

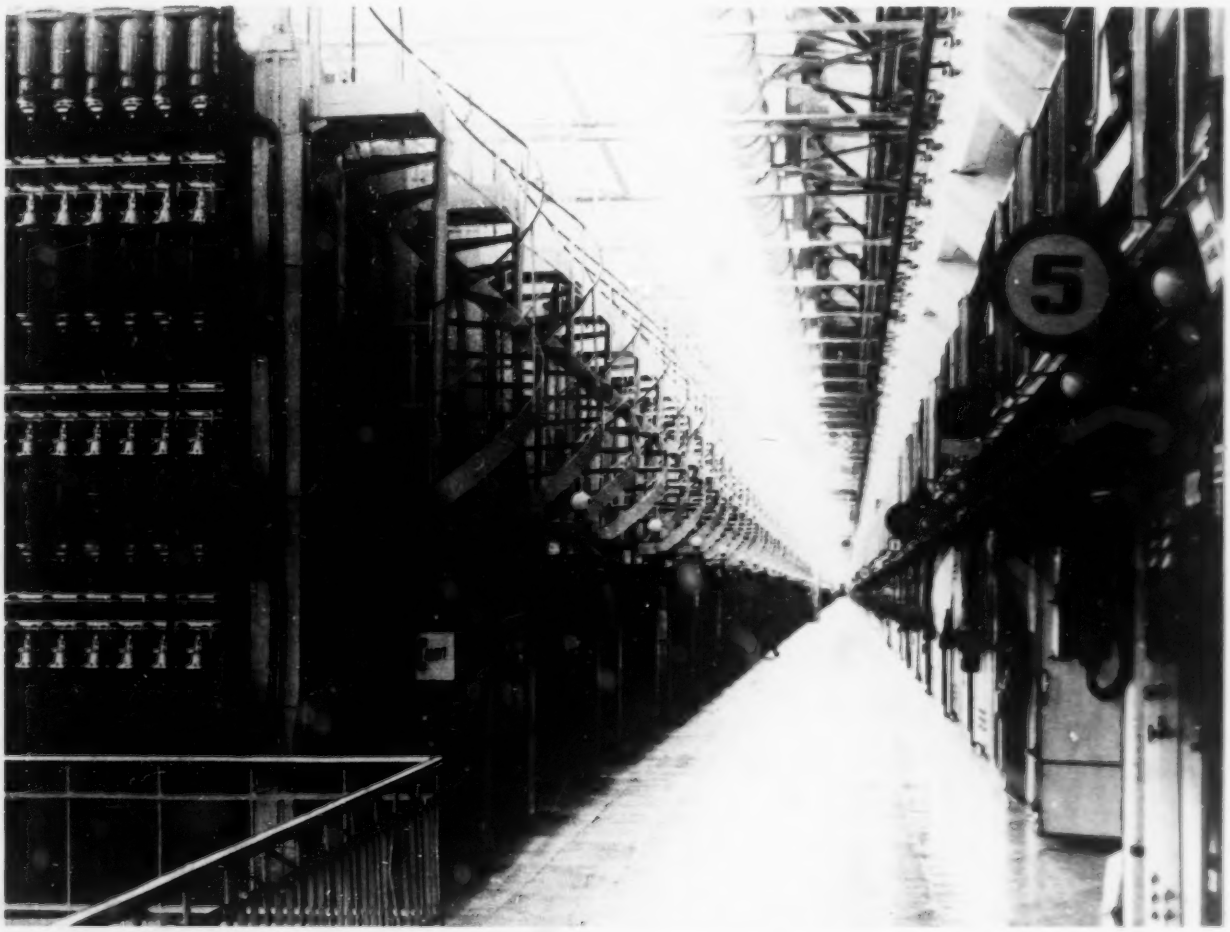

Figure 4 – Interior view (first of two; see also Figure 5) showing cascades at an operating gas centrifuge plant. *(Photo Courtesy of MAEI).*

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developed to make the process work. The pilot plant's first year of operation confirmed the reliability of centrifuges and their support systems, as well as the engineering and cost advantages of gas centrifuge technology compared to gaseous diffusion.

The first industrial gas centrifuge plant, containing several tens of thousands of centrifuges, was commissioned in 1959. It was used to test industrial centrifuge designs, as well as technological solutions adopted in the design of the industrial plant. Eventually, the USSR built an industrial plant with several hundred thousand subcritical centrifuges configured in three levels, and commissioned it in three stages (modules) in 1962-1964. The rotors of these centrifuges, which were made of aluminum alloy, needed almost no additional reinforcement, only small rings of reinforcing material in the area of the upper and lower covers of the rotor. The maximum number of centrifuges working in parallel in a stage at the first plant was 15,000. The configuration of machines in stages permitted faulty individual centrifuges to be replaced fairly simply. **Figure 4** and **Figure 5** show cascades at an operating gas centrifuge plant (location classified).

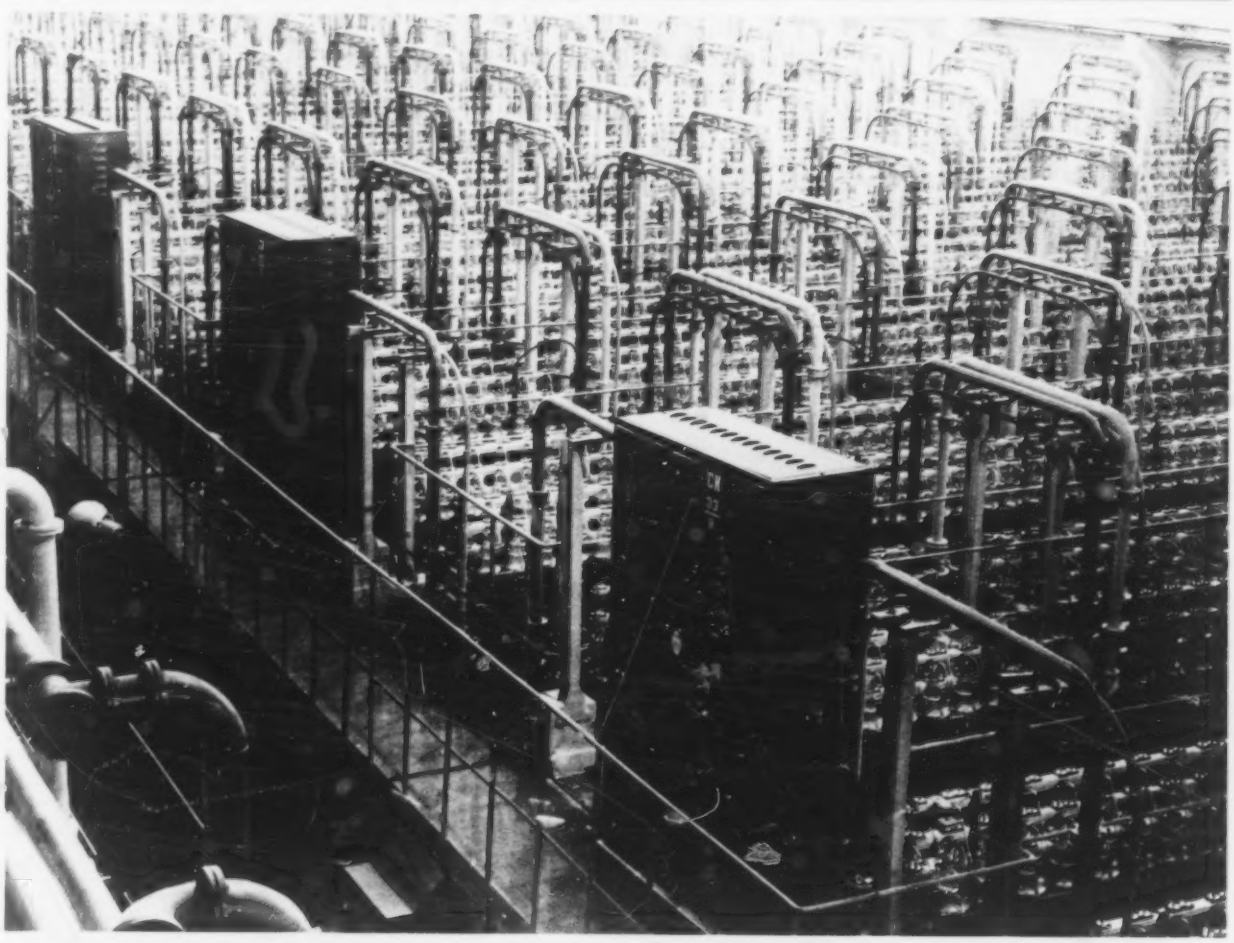

Figure 5 – Interior view (second of two; see also Figure 4) showing cascades at an operating gas centrifuge plant. *(Photo Courtesy of MAEI).*

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The axial circulation of gas in the rotor, as in subsequent centrifuge models, is accomplished through gas-dynamic braking of the UF_6 on a fixed separator (mechanical excitation). The first gas centrifuge designs installed at this plant ran for 10-12, years with a failure rate less than 1.5 percent per year, and were replaced by more productive and reliable models.

The stable operation and high productivity of a gas centrifuge cascade depends mainly on the reliable operation of the centrifuge itself, which, for all its apparent simplicity, is a very technically complex structure. So, from the first years of industrial use of centrifuge technology, strict feedback was set up between operations and manufacturing plants, drawing on the results of failure analysis of machines in the separating cascade to evaluate the effectiveness of gas centrifuge manufacturing technology.

The successful development of this system was a consequence of the development and introduction, as part of the technological process monitoring and control subsystem, of special devices that monitored the speed of each centrifuge's rotor at a rate of once per second and transmitted the address of each faulty machine to the operator's control panel. Modern designs improved substantially on the first gas centrifuges, both in productivity and in reliability. Existing centrifuges requiring 120-140 kW per SWU can operate non-stop for over 15 years with a failure level of only tenths of one percent per year. The increase in productivity achieved by increasing the velocity of rotation of the rotor is due to the application of materials with high specific strength, optimal use of mechanical property structure of the material, and improvement of the gas dynamic characteristics.

Gas centrifuge technology is also being used in the USSR for the separation of isotopes of other chemical elements. Industrial installations with gas centrifuges are supplying the demand for stable isotopes of iron, tungsten, xenon, sulphur, molybdenum and a number of other elements. Equipment has been developed for producing various radioactive isotopes such as ^{55}Fe and ^{85}Kr.

Conclusion

The Soviet Union began uranium enrichment in 1949 using the gaseous diffusion method to produce material for nuclear weapons. Soviet research on gas centrifuge enrichment technology initiated more than 40 years ago formed the basis for most of today's successful programs.

All production of highly-enriched weapons-grade uranium was completely halted in 1987. At present the Soviet Union is operating four enrichment plants, two of which also have facilities for conversion to UF_6. All four enrichment facilities have gas centrifuge units, and gaseous diffusion units contribute less than five percent of total SWU output.

The Soviet Union began selling enrichment services to West European customers in 1971, and deliveries to Western customers began in 1973. In the mid-1970s, V/O Techsnabexport concluded contracts with firms in almost all Western European countries. Many of these contracts extend through the year 2000, and some as far as 2010.

Because the rate of nuclear power additions was overestimated, and more recently as a reaction to the Chernobyl accident, substantial excess nuclear fuel cycle capacity has become available. More recently the cessation of all nuclear weapons uranium production has exacerbated the nuclear fuel cycle overcapacity situation, especially with respect to uranium enrichment. The Soviet Union at present makes available to the market three million SWU per year; that figure can grow to 10 million SWU per year by 1995 or 1996. That capacity can be put to several uses:

1. Separation of stable isotopes other than ^{235}U;
2. Export sales of SWU or enriched product;
3. Reenrichment of reprocessed uranium;
4. Enriching tails (depleted uranium) to the isotopic concentration of natural uranium (0.711% ^{235}U) or even higher.

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CALENDAR

NUCLEAR INDUSTRY CALENDAR

1991

April 14-17 ***INFO '91 Conference*** (The Westin Hotel, Chicago, Illinois).
Sponsored by the U.S. Council for Energy Awareness.
Contact: USCEA Conference Office; 202-293-0770; Telex: 7108249602; Fax: 202-785-4113.

April 14-18 ***Third International Conference on Nuclear Fuel Reprocessing & Waste Management*** (Sendai, Japan).
Sponsored by the Atomic Energy Society of Japan and the Japan Atomic Industrial Forum, and co-sponsored by the American Nuclear Society and the European Nuclear Society.
Contact: Japan Atomic Industrial Forum; 3-508-2411; or Fax: 3-508-2094.

April 21-24 ***International Topical Meeting on LWR Fuel Performance*** (Palais des Papes, Avignon, France).
Sponsored by the American Nuclear Society and the European Nuclear Society.
Contact: Fragema, BP3021, F69398 Lyon Cedex 03, France; Tel: (33) 74 72 8159; Fax: (33) 74 72 8760.

April 22-25 ***JAIF International Conference on Water Chemistry in Nuclear Power Plants*** (Fukui, Japan).
Contact: Japan Atomic Industrial Forum; 3-508-2411; or Fax: 3-508-2094.

May 2-3 ***Utility Nuclear Fuel Economics Group Meeting*** (Downtown Holiday Inn, Minneapolis, Minnesota).
Sponsored by Northern States Power.
Contact: David Austin; 612-330-7571.

May 8-10 ***Second International Conference on Transportation for the Nuclear Industry***
(Bournemouth, United Kingdom).
Co-Sponsored by the Institution of Nuclear Engineers, the European Nuclear Society, the American Nuclear Society, the Chartered Institute of Transport, and the Institution of Civil Engineers.
Contact: INE Conference Secretary; 081-698-1500 or 081-698-4750; Fax: 018-695-6409.

May 12-14 ***World Nuclear Fuel Market Annual Meeting*** (Atlanta, Georgia).
Contact: Donna Cason, World Nuclear Fuel Market; 404-447-1144.

May 14-16 ***Annual Meeting on Nuclear Technology '91*** (Hotel & Congress Center Maritim, Bonn, Germany).
Sponsored by the Kerntechnische Gesellschaft e.V. and the Deutsches Atomforum e.V.
Contact: INFORUM GmbH, Congress Office JK'91, Heussallee 10, D-5300 Bonn 1, or 0228/507 223.

June 2-6 ***American Nuclear Society Annual Meeting***
(Marriot Orlando World Center, Orlando, Florida).
Contact: ANS Meetings Department; 708-352-6611.

June 9-12 ***Nuclear Technology: Building Our Energy Future*** (Sheraton Cavalier Hotel, Saskatoon, Canada).
Sponsored by the Canadian Nuclear Association and the Canadian Nuclear Society.
Contact: Sylvie Caron, CNA; 416-977-6152; or Fax: 416-979-8356.

June 23-26 ***International Conference on Enrichment*** (The Westin Hotel, Washington, DC).
Sponsored by the U.S. Council for Energy Awareness.
Contact: USCEA Conference Office; 202-293-0770; Telex: 7108249602; Fax: 202-785-4113.

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Sept. 4-6 ***Uranium Institute Sixteenth Annual Symposium*** (London, UK).
Contact: Uranium Institute; 44-71-225-0303; or Fax: 44-71-225-0308.

Sept. 22-25 ***International Uranium Seminar '91*** (The Don Cesar Hotel, St. Petersburg/Tampa, Florida).
Sponsored by the U.S. Council for Energy Awareness.
Contact: USCEA Conference Office; 202-293-0770; Telex: 7108249602; Fax: 202-785-4113.

Sept. 29-Oct. 2 ***American Mining Congress Mining Convention*** (Salt Lake City, Utah).
Contact: AMC Convention Office: 202-861-2800; or Fax: 202-861-7535.

Oct. 29-31 ***Uranium Hexafluoride Handling*** (William G. Pollard Auditorium, Oak Ridge, Tennessee).
Sponsored by Martin Marietta Energy Systems, Inc.
Contact: Diane Duck, MMES, 615-576-1676; or Fax: 615-576-1561.

Nov. 10-13 ***Nuclear Energy Forum*** (Westin St. Francis Hotel, San Francisco, California).
Sponsored by the U.S. Council for Energy Awareness.
Contact: USCEA Conference Office; 202-293-0770; Telex: 7108249602; Fax: 202-785-4113.

Nov. 10-15 ***American Nuclear Society Winter Meeting*** (Hilton Hotel, San Francisco, California).
Contact: ANS Meetings Department; 708-352-6611.

1992

April 12-16 ***8th Pacific Basin Conference*** (Taipei, Taiwan).
Sponsored by the Amercian Nuclear Society.
Contact: ANS Meetings Department; 708-352-6611.

Sept. 21-23 ***Second International Conference on Training for Operation & Maintenance in the Nuclear Industry***
(The Moat House International Hotel, Stratford-upon-Avon, United Kingdom).
Sponsored by the Institution of Nuclear Engineers.
Contact: INE Conference Secretary; 081-698-1500 or 081-698-4750; Fax: 018-695-6409.

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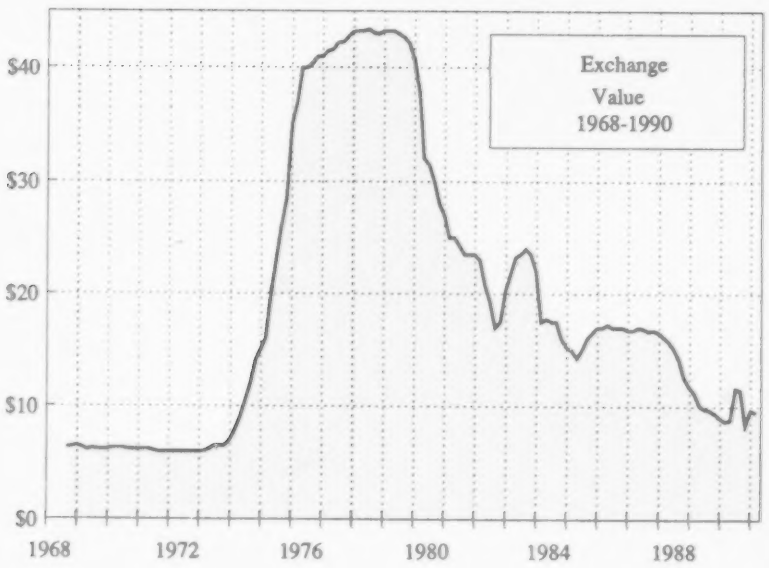
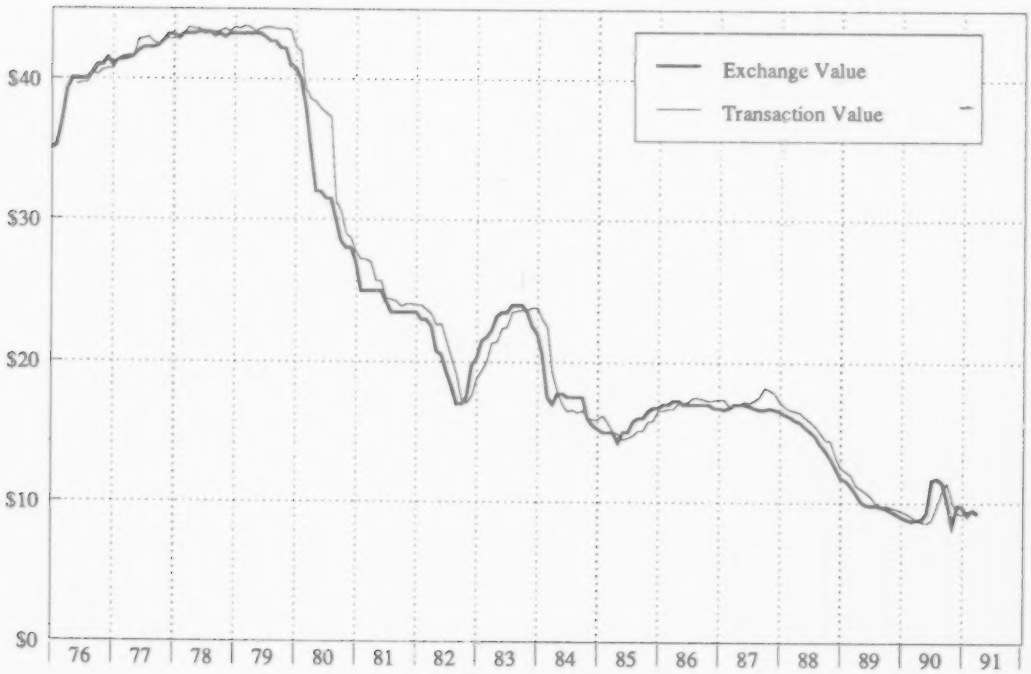
HISTORICAL MARKET DATA

NUEXCO Historical Exchange Value and Transaction Value
(in US dollars per Pound U_3O_8)





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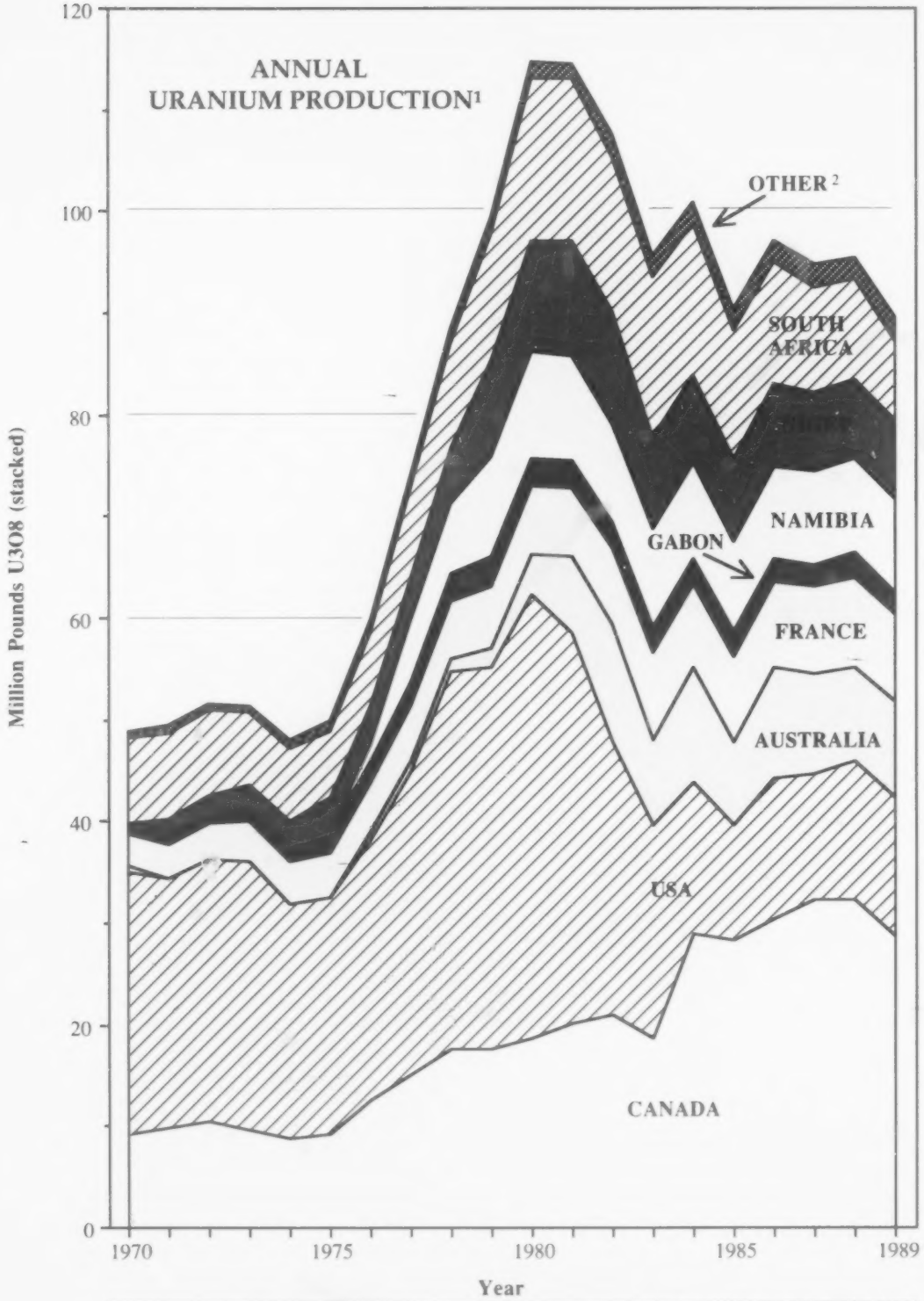

[1] Estimated world production in 1989 totalled 89.6 million pounds (Australia—9.5; Canada—28.7; France—8.5; Gabon—2.2; Namibia—9.2; Niger—7.7; South Africa—7.7; USA—13.7; Others[2]—2.3).

[2] **Other** includes: Argentina, Belgium, Brazil, India, Pakistan, Portugal, Spain, (West) Germany, and Yugoslavia

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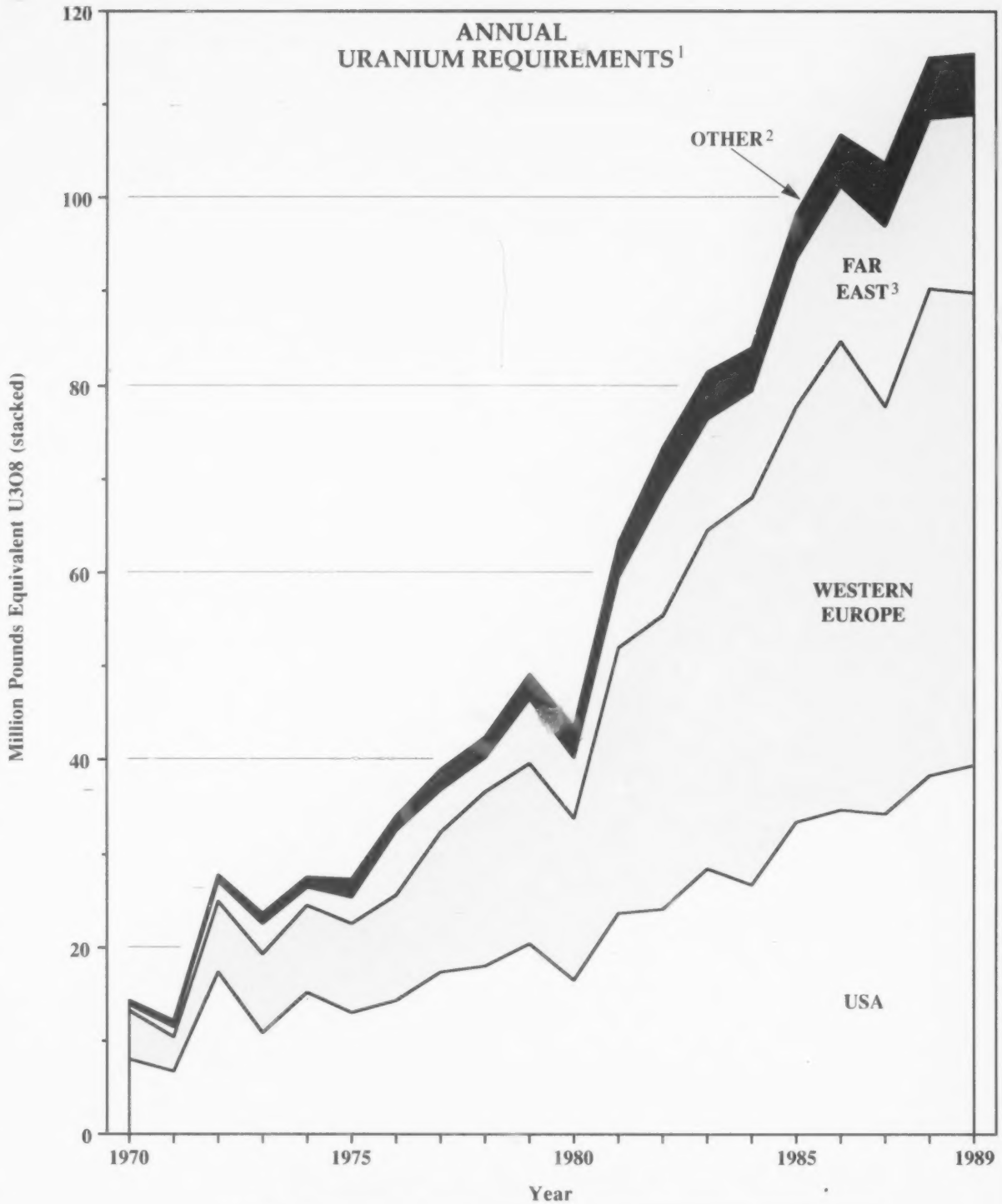
HISTORICAL MARKET DATA



[1] Calculated by NUEXCO based on actual completion dates and operating performance, and NUEXCO's estimate of enriching tails assays.

[2] **Other** include: Argentina, Brazil, Canada, India, Mexico, Pakistan and South Africa.

[3] Does not include Peoples Republic of China.

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HISTORICAL MARKET VALUES

Exchange Values

Determined as of the last day of the month indicated ($US/lb U_3O_8)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	16.90	16.75	16.65	16.65	16.75	16.65	16.55
1988	16.30	16.15	15.90	15.75	15.40	15.10	14.75	14.15	13.75	13.15	12.50	11.75
1989	11.60	11.20	10.70	10.10	9.85	9.80	9.80	9.70	9.60	9.40	9.20	9.00
1990	8.85	8.70	8.80	8.80	9.25	11.60	11.70	11.45	10.10	8.35	9.80	9.70
1991	9.10	9.50	**9.30**									

US Premium (Relative to the Exchange Value)

Determined as of the last day of the month indicated ($US/lb U_3O_8)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	0.65	0.75
1987	0.85	1.00	1.50	1.50	0.90	0.60	2.50	2.35	2.10	1.65	0.85	0.65
1988	0.70	0.50	0.15	0.25	0.60	0.00	0.00	0.00	0.00	0.00	**Discontinued**	

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HISTORICAL MARKET DATA

UF_6 Values

Year	Determined as of the last day of the month indicated ($US/kg U as UF_6)											
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	47.75	47.50	47.00	46.75	47.00	47.00	47.00
1988	46.50	46.00	45.50	45.25	44.75	44.00	42.75	41.00	40.75	39.00	37.50	35.50
1989	34.75	34.00	33.00	30.50	30.25	30.25	30.00	29.75	29.75	28.25	27.75	26.50
1990	25.90	25.25	24.40	24.40	25.50	32.00	32.50	32.25	29.50	24.75	28.75	28.75
1991	27.50	27.75	**27.50**									

US Premium (Relative to the UF_6 Value)

Year	Determined as of the last day of the month indicated ($US/kg U as UF_6)											
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	2.50	2.50
1987	2.50	2.50	3.50	3.00	2.25	1.75	6.50	6.00	4.25	3.10	2.25	2.00
1988	1.25	1.25	0.50	0.50	1.00	0.00	0.00	0.00	0.00	0.00	**Discontinued**	

Conversion Values

Year	Determined as of the last day of the month indicated ($US/lb U as UF_6)											
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.90	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.90	1.90	1.90
1988	1.90	1.80	1.80	1.80	1.80	1.80	1.85	1.95	1.95	1.95	1.95	1.95
1989	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.90	1.90	1.80	1.75	1.65
1990	1.50	1.50	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
1991	1.45	1.45	**1.45**									

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Transaction Values

Determined as of the last day of the month indicated ($US/lb U_3O_8)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	17.10	17.30	17.55	18.20	18.05	17.80	17.20
1988	16.85	16.65	16.55	16.45	16.10	15.80	15.45	15.00	14.50	14.40	13.30	12.50
1989	12.25	12.00	11.25	11.00	10.75	10.45	9.95	9.80	9.80	9.65	9.55	9.40
1990	9.25	9.05	8.75	8.65	8.55	8.80	9.75	10.80	11.40	10.10	9.30	9.15
1991	9.40	9.45	**9.35**									

SWU Values

Determined as of the last day of the month indicated ($US per SWU)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1986	80	80	80	80	75	78	78	78	78	78	80	80
1987	80	80	77	77	75	73	75	75	73	69	73	73
1988	73	73	70	68	68	68	68	65	65	65	65	65
1989	65	67	67	67	66	66	66	65	63	59	57	54
1990	54	50	50	50	50	50	50	50	50	51	51	51
1991	51	50	**52**									

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HISTORICAL MARKET DATA

Loan Rates

Determined as of the last day of the month indicated (Percent per Annum)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	4.00	4.00	4.00	4.00	4.00
1969	4.00	4.00	5.00	5.00	5.00	5.00	5.00	5.00	6.00	6.00	6.00	6.00
1970	6.00	6.20	6.40	6.50	6.50	6.50	6.50	5.00	6.50	6.00	5.50	5.50
1971	5.00	4.75	4.75	4.75	5.00	5.25	5.25	5.25	5.25	5.25	4.50	4.50
1972	4.00	4.00	4.00	4.50	4.50	4.50	5.00	5.00	5.00	5.00	5.00	5.00
1973	5.50	5.50	5.75	5.75	6.00	6.25	7.00	7.00	7.00	7.00	7.50	8.00
1974	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
1975	8.00	7.00	7.00	7.00	7.00	6.50	6.50	6.50	6.50	6.50	6.50	6.50
1976	6.50	6.50	6.50	6.50	*	*	*	*	*	*	*	*
1977	*	*	*	*	6.50	6.50	6.50	6.75	7.25	7.25	7.25	7.25
1978	7.25	7.00	7.00	7.00	7.00	7.50	7.75	7.75	7.75	7.00	7.00	7.00
1979	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1980	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1981	7.00	7.00	7.00	7.00	7.00	5.50	5.50	5.50	5.50	6.00	6.00	6.00
1982	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
1983	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
1984	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
1985	6.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
1986	5.00	5.00	5.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
1987	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00	3.50	3.50
1988	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
1989	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
1990	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
1991	3.50	3.50	**3.50**									

* Float with Prime Rate

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Australia

Year	Period [1]	Consumer Price Index [2] (1980/1981 = 100)	Price Index of Materials Used in Manufacturing Industry — All Groups [3] (1984/1985 = 100)	Average Weekly Ordinary Time Earnings — Adult Males — Australia [4] (Australian dollars)	Award Rates of Pay Indexes Australia - Adult Males In Mining Wage Earners, Weekly Rates [5] (June 1985=100)
1980	Avg.	95.8	83.1	—	140.8 [6]
1981	Avg.	105.0	85.9	—	154.1 [6]
1982	Avg.	116.7	89.0	—	174.9 [6]
1983	Avg.	128.5	96.9	—	181.9 [6]
1984	Avg.	133.6	98.0	—	194.4 [6]
1985	Avg.	142.6	107.3	—	103.7
1986	Avg.	155.5	101.5	—	106.1
1987	Avg.	168.7	108.9	465.88	112.3
1988	Avg.	180.9	111.8	496.90	115.2
1989	Avg.	194.6	117.0	534.65	126.0
1990	Avg.	208.7	123.4	—	129.3
Jan	1990	—	119.2	—	128.3 R
Feb	1990	—	120.8	555.80	128.3 R
Mar	1990	204.1	121.5	—	128.5 R
Apr	1990	—	119.9	—	128.7 R
May	1990	—	118.9	566.60	128.9 R
June	1990	207.4	116.6	—	129.5 R
July	1990	—	116.4	—	129.6 R
Aug	1990	—	122.4	574.10	129.7 R
Sept	1990	208.9	128.2	—	130.1 R
Oct	1990	—	134.1	—	130.1 R
Nov	1990	214.5	133.7	—	130.1 R
Dec	1990	—	128.8	—	130.2 R
Jan	1991	—	—	—	130.1

P = Preliminary **R** = Revised since last month

[1] Monthly data for the period 1967 to 1986 appears in Report 233 (January 1988).
[2] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: Financial year July 1980 to June 1981 = 100.0). Figures shown at end of quarter represent quarterly average.
[3] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0).
[4] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.
[5] Australian Bureau of Statistics, Canberra: "Average Weekly Earnings, States & Australia" (Catalogue No. 6302.0).
[6] Base: June 1976 = 100.

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GOVERNMENT STATISTICS

Canada

		Industrial Products Price Index: All Commodities [1] (1986 = 100) [2]	Consumer Price Index: All Items (1986 = 100) [3]	Wage-earner Data: Average Hourly Earnings (C$) [4] Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells (SIC 051-099)	Metal Rolling, Casting and Extruding (SIC 298)	Chemicals and Chemical Products Industries (SIC 372-379)
1980	Avg.	75.7	67.1	–.–	–.–	–.–	–.–	–.–
1981	Avg.	83.4	75.5	–.–	–.–	–.–	–.–	–.–
1982	Avg.	89.0	83.7	–.–	–.–	–.–	–.–	–.–
1983	Avg.	92.1	88.5	17.22	–.–	14.18	10.67	11.10
1984	Avg.	96.3	92.3	17.89	–.–	14.97	11.11	11.68
1985	Avg.	99.0	96.0	18.53	16.48	15.56	11.85	12.12
1986	Avg.	100.0	100.0	19.38	16.70	15.76	12.28	12.58
1987	Avg.	102.4	104.4	20.12	17.15	16.11	12.58	13.20
1988	Avg.	106.9	108.6	20.91	18.51	16.95	13.17	13.77
1989	Avg.	109.4	114.0	21.97	20.02	18.41	13.71	14.16
1990	Avg.	109.7	119.4	22.90	20.93	19.12	14.62	15.28
Jan	1990	108.7	116.9	21.88	20.39	19.03	13.99	14.78
Feb	1990	109.5	117.6	22.51	20.63	19.14	14.49	15.03
Mar	1990	109.3	118.0	22.52	20.75	19.17	14.99	15.07
Apr	1990	109.1	118.1	23.17	21.20	19.46	14.83	14.93
May	1990	109.6	118.7	23.28	20.55	19.01	14.71	15.06
June	1990	109.4	119.2	21.85	20.63	18.96	14.69	15.05
July	1990	109.1	119.8	20.92	20.18	18.66	14.34	15.20
Aug	1990	109.3R	119.8	23.88	20.51	18.59	14.50	15.33
Sept	1990	110.2	120.2	24.41	21.19	18.94	14.48	15.63
Oct	1990	110.7R	121.2	23.11	21.39	19.12	14.78	15.59
Nov	1990	111.0R	121.9	23.38	21.83	19.48	14.93	15.73
Dec	1990	111.0R	121.8	23.90R	21.89R	19.88R	14.73R	16.01R
Jan	1991	111.1R	125.0	23.06P	21.57P	19.71P	14.66P	15.84P
Feb	1991	110.8	125.0	–.–	–.–	–.–	–.–	–.–

P = Preliminary **R** = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Monthly data for the period 1967 to 1986 is found in Report 233.

[2] New Base Year of 1986 as of Report 266. Previous Base Year was 1981. All figures in column recalculated by 0.791 multiplier.

[3] New Base Year of 1986 as of Report 264. Previous Base Year was 1981. All figures in column recalculated by 0.755 multiplier.

[4] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours." Monthly data for the period 1983 to 1986 is found in Report 233.

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South Africa

		Average Declared Working Costs per Metric Ton of Gold Ore Milled [1] (Rand)	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled [2] (March 1982 = 100)	Consumer Price Index [3] (1985 = 100)	Production Price Index All Groups [4] (1985 = 100)	Total Employment in Mining and Quarrying [5]	Total Salaries and Wages in Mining and Quarrying [5] (1,000 Rand)
							Annual Total [6]
1980	Avg.	35.53	—	51.9	55.2	709,042	2,237,689
1981	Avg.	41.89	—	59.8	62.7	722,918	2,756,928
1982	Avg.	47.25	104.2	68.6	71.4	702,041	3,181,584
1983	Avg.	51.88	115.0	77.1	79.0	700,901	3,563,282
1984	Avg.	58.95	130.3	86.0	85.6	711,511	4,134,390
1985	Avg.	68.76	151.6	100.0	100.0	724,587	4,778,612
1986	Avg.	80.22	177.9	118.6	119.5	756,637	5,767,950
1987	Avg.	95.01	223.1	137.7	136.2	751,864	6,911,395
1988	Avg.	106.69	241.1	155.4	154.1	705,355	7,774,054
1989	Avg.	116.65	273.0	178.2	177.5	700,360	8,833,934
1990	Avg.	129.37	305.3	203.8	199.4	—	—
							Monthly Total
Jan	1990	—	—	192.0	188.8	688,837	801,616
Feb	1990	—	—	193.3	190.3	674,026	767,274
Mar	1990	126.74	296.3	196.4	190.9	704,660	780,614
Apr	1990	—	—	198.3	194.1	696,107	810,474
May	1990	—	—	200.4	196.3	613,527	719,191
June	1990	128.25	299.87	201.8	197.0	676,621	841,165
July	1990	—	—	203.2	197.2	697,242	913,177
Aug	1990	—	—	206.5	199.8	686,385	902,392
Sept	1990	129.46	312.55	209.7	203.2	689,317	922,454
Oct	1990	—	—	211.1	206.1	676,833	882,603
Nov	1990	—	—	215.6	214.9	669,198	909,418
Dec	1990	133.02	312.37	217.1	214.7	—	—
Jan	1991	—	—	219.5	218.0	—	—
Feb	1991	—	—	222.2	—	—	—

P = Preliminary **R** = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly. Historical Data by month appears in Report 236.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Central Statistical Service, Pretoria: All income groups-weighted average, Historical Data by month appears in Report 236.

[4] Central Statistical Service, Pretoria: All commodities for consumption in South Africa.

[5] Central Statistical Service, Pretoria: Historical Data by month appears in Report 236.

[6] Annual total is shown, rather than monthly average, for indicated year.

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GOVERNMENT STATISTICS

United States

		Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4]			
		Industrial Commodities (1982 = 100)	All Commodities (1982 = 100)	(1982-1984 = 100)	(1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980	Avg.	88.0	89.8	82.4	85.7	10.26	10.63	8.30	6.94
1981	Avg.	97.4	98.0	90.9	94.0	11.55	11.98	9.12	7.62
1982	Avg.	100.0	100.0	96.5	100.0	12.31	12.93	9.96	8.21
1983	Avg.	101.1	101.3	99.6	103.9	12.58	13.43	10.58	8.67
1984	Avg.	103.3	103.7	103.9	107.7	13.05	13.43	11.07	9.04
1985	Avg.	103.7	103.2	107.6	110.9	13.38	13.74	11.56	9.46
1986	Avg.	100.0	100.2	109.6	113.9	12.46	13.48	11.98	9.65
1987	Avg.	102.6	102.8	113.6	117.7	12.52	12.98	12.37	9.88
1988	Avg.	106.3	106.9	118.3	121.3	13.24	13.26	12.71	9.79
1989	Avg.	111.6	112.2	124.0	126.3	13.59	13.72	13.09	10.05
1990	Avg.	115.8	116.3	130.7	131.5	14.10R	14.36	13.54	10.37
Jan	1990	114.1	114.9	127.4	—	13.69	13.95	13.34	10.13
Feb	1990	113.6	114.4	128.0	—	13.70	13.99	13.27	10.16
Mar	1990	113.2	114.2	128.7	129.7	13.80	14.04	13.34	10.17
Apr	1990	113.2	114.1	128.9	—	13.92	14.30	13.53	10.17
May	1990	113.5	114.6	129.2	—	13.96	14.16	13.46	10.22
June	1990	113.2	114.3	129.9	131.0	14.00	14.31	13.51	10.27
July	1990	113.4	114.5	130.4	—	14.29	14.49	13.58	10.34
Aug	1990	115.9	116.5	131.6	—	14.27	14.60	13.57	10.33
Sept	1990	118.4	118.4	132.7	132.2	14.41	14.48	13.62	10.42
Oct	1990	121.4R	120.8	133.5	—	14.43	14.58	13.72	10.47
Nov	1990	120.6	120.1	133.8	—	14.34	14.73	13.73	10.53
Dec	1990	118.9	118.6	133.8	133.1	14.39R	14.69R	13.75	10.57
Jan	1991	118.3	118.9	134.6	—	14.65P	14.67P	13.83R	10.60R
Feb	1991	117.2	117.2	134.8	—	– - –	– - –	13.78P	10.58P

P = Preliminary **R** = Revised since last month

[1] US Bureau of Labor Statistics, Washington, DC: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents. Historical data is presented in Report 233.

[2] US Bureau of Labor Statistics, Washington, DC: Consumer Price Index for All Urban Consumers, US City Average, All Items. Historical data is presented in Report 233.

[3] US Department of Commerce, Washington, DC: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted. Historical data is presented in Report 233.

[4] US Bureau of Labor Statistics, Washington, DC: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Historical data is presented in Report 233.

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Volume and Price of Uranium Deliveries To The European Community [1]

— Compiled from data published by the Euratom Supply Agency —

Year	Volume of Deliveries to the EC [2] (MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts [3] Average Price		Spot Contracts [3] Average Price	
			in ECU per pound U_3O_8	in US Dollars per pound U_3O_8	in ECU per pound U_3O_8	in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00
1986	12,000	9.5	ECU 31.50	$31.00	ECU 18.00	$17.75
1987	14,000	17.0	ECU 28.25	$32.50	ECU 15.00	$17.25
1988	12,500	4.5	ECU 26.92	$31.82	ECU 13.65	$16.13
1989	13,500	11.5	ECU 26.63	$29.35	ECU 11.04	$12.19

P = Preliminary **R** = Revised since last month

[1] The twelve European Community member nations are Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EEC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar. Exchange rates are published by European Communities Statistical Office and the International Monetary Fund.

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GOVERNMENT STATISTICS

US Uranium Marketing Activities Statistics

— Compiled from data published by the US Energy Information Administration [1] —

Year	Total Production (million pounds U_3O_8)	Deliveries to Domestic Utilities From US Suppliers [2] (million pounds U_3O_8)	Average Price of Delivered Uranium [2] ($/lb. U_3O_8)	Quantity of Uranium Imported [3] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	27.6	$16.10	3.6	n/a	1.2
1977	29.9	27.8	$19.75	5.6	n/a	4.0
1978	37.0	31.6	$21.60	5.2	n/a	6.8
1979	37.5	33.0	$23.85	3.0	n/a	6.2
1980	43.7	35.0	$28.15	3.6	$43.10	5.8
1981	38.5	32.6	$34.65	6.6	$32.90	4.4
1982	26.9	23.5	$38.37	17.1	$25.19	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3
1986	13.5	18.9	$30.01	13.5	$20.07	1.6
1987	13.0	20.8	$27.37	15.1	$19.14	1.0
1988	13.1	17.6	$26.15	15.8	$19.03	3.3
1989	13.8	18.4	$19.56	13.1	$16.75	2.1

P = Preliminary **R** = Revised since last month

[1] Sources: 1976-1983: US Department of Energy/Energy Information Administration, *Survey of United States Marketing Activity*.
1984-1989: Energy Information Administration, *Uranium Industry Annual*.

[2] Data for 1976-1981 includes both domestic utilities and agents.

[3] Includes imports by domestic utilities and domestic suppliers.

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